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CONTENTS

Authors are alone responsible for their respective statements.

No. 1. **July 1919.**

Page

Address at the Anniversary Meeting, 2 June 1919. Colonel Sir Thomas H. Holdich, President 1

Geographical Work with the Army in France. Lieut.-Colonel H. S. L. Winterbotham, C.M.G., D.S.O., R.E. (4 *Plates*) 12

The Prismatic Astrolabe. John Ball, O.B.E., D.SC., M.INST.C.E., of the Survey of Egypt, and H. Knox-Shaw, M.A., Director of Helwan Observatory (5 *Diagrams*) 29

The Origin of the Hereros and Ovambo. Professor E. H. L. Schwarz, Rhodes University College 46

Southampton Island. Captain H. T. Munn (*Sketch-map*) 52

Reviews :—

Luxemburg and Her Neighbours. O. J. R. H. — A Broken Journey. C. H. H. — The Bantu Languages. H. H. Johnston. — Through Egypt in War-Time. F. R. C. — Life of Frederick Courtney Selous, D.S.O. F. R. C. 55

The Monthly Record :—

The Port of Rouen and the War.—The Himalayan Problem.—Mean Sea-Level and Precise Levelling in Canada. A. J. Wolff, Major R.E. —The San Salvador Earthquake of 28 April 1919.—"Continentality" and Temperature with Special Reference to Glaciation.—The Earth's Interior.—The Hakluyt Society 60

Correspondence—Physical and Strategic Geography of the Adriatic. Jovan Cvijić and Commander Roncagli.—Motor *versus* Rail in Persia. Lieut.-Col. George S. F. Napier 65

Meetings : Royal Geographical Society : Session 1918–1919 . . . 69

Map.

Sketch-map of Southampton Island to illustrate paper by Capt. H. T. Munn 53

No. 2. **August 1919.**

The Exploration of Manchuria. Captain Arthur de C. Sowerby, F.Z.S. (*Sketch-map and* 4 *Plates*) 73

Marco Polo's Account of a Mongol Inroad into Kashmir. Sir Aurel Stein, K.C.I.E. 92

Boundary Delimitations in the Treaty of Versailles. A. R. H. (*Sketch-map*) 103

Geographical Names for British Official Use 113

Reviews :—

Il Ticino. L. C. M. — Depois do Terremoto. M. L. D. — Nuzhat-al-Qulūb. P. M. S. — Le Maroc Economique et Agricole. F. R. C.— A School Geography of Fiji. B. G. C.—History of Samoa. B. G. C. 115

The Monthly Record :—

The Earliest Printed Maps of the British Isles.—Recent Earthquakes in Greece.—The Names of New States.—Restoration of the Library of Louvain. Early Accounts of Mount Brown and Mount Hooker,

Page

Canadian Rockies.—New Railway from Bogotá to the Magdalena, Colombia.—The Kauri Forests of New Zealand.—Another Antarctic Ship lost.—International Hydrographic Conference.—A World-map by Hondius on Mercator's Projection 119
Correspondence—The Voyage of Carstensz to Australia. W. Siebenhaar 123
Anniversary Dinner: Royal Geographical Society 124

Maps.

Sketch-map of Manchuria to illustrate paper by Captain Sowerby . . 76
Sketch-map of Upper Silesia to illustrate paper on Boundary Delimitations 109

No. 3. September 1919.

Crete: its Scenery and Natural Features. A. Trevor-Battye, M.A. (*with 5 Plates, Diagram, and Sketch-map*) 137
The Paraguayan Chaco and its Possible Future. W. Barbrooke Grubb (*with 2 Plates and Sketch-map*) 157
Hondius and his Newly-found Map of 1608. E. Heawood (*with Diagm.*) 178
The Boundaries of Čecho-Slovakia. A. R. H. 185
Reviews:—
The Congress of Vienna, 1814–15.—Subsidios para o Estudo das Relações exteriores de Portugal (1640–1649). M. L. D.—The Long Road to Baghdad. H. Charles Woods.—Native Races and their Rulers. F. R. C.—The Pacific: its Past and Future. B. G. C. . 188
The Monthly Record:—
Permanent Scottish Snow-beds.—Physics of the Crust in Central Asia.—The Course of the Niger.—The Houtmann "Abrolhos," Western Australia.—A Sixteenth-Century Globe-Cup (*with Plate*).—British Rainfall Organization: Retirement of Dr. H. R. Mill.—New Geographical Appointments.—Retirement of Capt. D. Wilson Barker.—Committee on Geographical Names 193
Obituary—The Right Hon. Sir W. Macgregor, M.D., P.C., G.C.M.G. G. R. Le Hunte.—Colonel F. P. Washington 198
Correspondence—Air Photography of Ancient Sites. Sir Aurel Stein . 200

Maps.

Crete, to illustrate paper by A. Trevor-Battye . . . . *facing* 140
Sketch-map of the Paraguayan Chaco, to illustrate paper by W. Barbrooke Grubb 162

No. 4. October 1919.

Geological Work on the Western Front. W. B. R. King, O.B.E. (Captain R.W.F., formerly Geologist to Engineer-in-Chief, G.H.Q., France) (*with 2 Plates*) 201
Irrigation in the United States. R. H. Whitbeck, Professor of Geography, University of Wisconsin, Madison (*with 2 Sketch-maps and 4 Plates*) 221
On the Possible Prolongation of the Himalayan Axis beyond the Dihang. F. Kingdon Ward (*with Sketch-map and Diagram*) 231
Economic Notes on Eastern Tibet. Oliver Coales, H.B.M. Consular Service (*with folding Map*) 242

Page

Light Railways in New Countries. Major W. Waters Van Ness, R.E. . 247
Problems of Eastern Europe (Review). M. A. Czaplicka. 249
Reviews :—
Wanderings in Italy ; Byways in Southern Tuscany. L. C. M.—The Land of Promise. E. W. G. M.—A Comparative Study of the Bantu and Semi-Bantu Languages. A. S.—Transsahariens et Transafricains. F. R. C.—The Illinois and Michigan Canal. L. E. E.—The Danish West Indies under Company Rule. E. A. B.—Handbook of Travel; prepared by the Harvard Travellers' Club. J. W. Evans and E. A. R. 252
The Monthly Record :—
Audibility of Gun-fire in S.E. England.—Dr. Oudney's Grave in Nigeria.—Lakes of Epsomite on the Washington–British Columbia Border.—Sea-lions and Fisheries on the Coast of British Columbia.—Prospecting in South-Western Tasmania.—Atlantic Currents and Escaped Mines 258
Correspondence—The Prismatic Astrolabe. John Ball and H. Knox-Shaw 262

Maps.

Two Sketch-maps to illustrate the paper by Prof. R. H. Whitbeck on Irrigation in the United States 222, 226
Sketch-map to illustrate the paper by F. Kingdon Ward on the Possible Prolongation of the Himalayan Axis beyond the Dihang . . . 233
Mr. Oliver Coales' Route from Tachienlu to Ch'amdo and Riwoch'e (*folding map*) . . . . . *following* 264

No. 5. November 1919.

The Desert Crossing of Hsüan-tsang, 630 A.D. Sir Aurel Stein, K.C.I.E., (*with Plate Map*) 265
The Kasempa District, Northern Rhodesia. F. H. Melland, Magistrate for the District (*with Sketch-map and 4 Plates*) 277
The New Boundaries of Austria (*with folding Map*) 288
The Aeroplane in African Exploration. Lieut. Leo Walmsley, M.C. (late flying-officer observer with the 26th (South African) Squadron R.F.C.) (*with 2 Plates*) 296
The Irrigation of the Konia Plain. R. I. Money, M.INST.C.E. (*with Sketch-map and 2 Plates*) 298
The International Rivers of Europe. Professor L. W. Lyde, M.A. . . 303
Reviews :—
Colonias Portuguesas. M. L. D.—Portugal Colonial. M. L. D.—La Vénétie Julienne et la Dalmatie. L. C. M.—A Brief Record of the Advance of the Egyptian Expeditionary Force under the Command of General Sir Edmund H. H. Allenby, G.C.B., G.C.M.G. E. W. G. M.—Farming and Planting in British East Africa. F. R. C.—Unconducted Wanderers. B. G. C.—International Rivers : a Monograph based on Diplomatic Documents. A. G. . . . 313
The Monthly Record :—
Precipitation in Mountains, particularly the Italian Alps.—The Flora of Tenerife and its Regional Distribution.—Fuels of Western Canada.—The Gordon River, Western Tasmania.—A Model of Kilauea Volcano, Hawaii.—A Large Crater in Iceland.—Unrecorded Early Voyages to Spitsbergen ?—Corrupted Names in the Indian Ocean . 319

Page

Obituary—Professor Leonard King.—Lieut.-Colonel Bertram F. E. Keeling, M.C., R.E.—James McCarthy—Rev. Henry Lansdell, D.D.—Lieut.-Colonel Sir Henry Trotter, K.C.M.G., C.B. 325
Correspondence—Names in the Čecho-Slovak States. R. Huvar . . 328

Maps.

Map showing the route of Hsüan-tsang . . . . . *facing* 269
Sketch-map of the Kasempa District, Northern Rhodesia . . . 279
Sketch-map to illustrate Mr. Money's article on the Irrigation of the Plain of Konia 300
Map to illustrate the New Boundaries of Austria . . . *following* 328

No. 6. December 1919.

Central Kurdistan. Major Kenneth Mason, M.C., R.E. (*with 2 Sketch-maps and 4 Plates*) 329
Missing Links in the Development of the Ancient Portuguese Cartography of the Netherlands East Indian Archipelago. E. C. Abendanon . 347
Reminiscences of the Map of Arabia and the Persian Gulf. Lieut.-Colonel F. Fraser Hunter, D.S.O., I.A. 355
The Progress of Boundary Delimitation in Europe. A. R. H. (*with Sketch-map*) 363
Vilkitski's North-East Passage, 1914–15 367
Geography at the British Association. 375
Boundary between Alberta and British Columbia. E. A. Reeves . . 381
Reviews:—
The Rise of the Spanish Empire. E. A. B.—Indo-China and its Primitive People. E. A. P.—With the British Army in the Holy Land. E. W. G. M.—In and about Palestine with Notebook and Camera. E. W. G. M.—A Description of the Historic Monuments of Cyprus. J. L. M.—Le Maroc: Les Ressources de ses Régions; Sa mise en Valeur.—Modern Morocco: A Report on Trade Prospects.—Nomads et Sédentaires au Maroc. F. R. C.—The Five Republics of Central America. L. E. E. 382
The Monthly Record:—
The Port and Roadstead of Brest.—French Places designated "Allemand."—Torrential Phenomena on the Eastern Edge of the "Massif Central" of France.—Swedish Exploration in Celebes.—Aerial Reconnaissance in the Atlas of Morocco.—Explorations in the Yukon Territory.—Distribution of Fishes off the Eastern Coasts of Canada.—Geography at Manchester.—Gilchrist Studentship . . 389
Obituary—Lieut.-Colonel W. A. L. Fletcher, D.S.O.—Prof. F. J. Haverfield.—James McCarthy. R. W. G. and A. J. I.—Arthur Neve. Tom G. Longstaff 394
Correspondence—The Discovery of Dr. Oudney's Grave. E. Wm. Bovill 398
Meetings: Royal Geographical Society: Session 1919–1920 . . . 398
Index 399

Maps.

Sketch-map of Kurdistan, 1/3·5 M 332
Sketch-map of Central Kurdistan, 1/1·2 M 337
Key to Progress of Boundary Delimitation in Europe 365

The Geographical Journal

Vol. LIV No. 1 July 1919

ADDRESS AT THE ANNIVERSARY MEETING, 2 June 1919

Colonel Sir Thomas H. Holdich, President

IN making a brief reference to our activities and experiences of the last year I find the Society to be once again in the position of having no important geographical history. There have been few expeditions into new spaces of the unmapped world; no thrilling experiences of contact with what may prove to be new groups of humanity, but which must be of the deepest interest because they are really the survivals of prehistoric races; no elementary map-making of the floor of the ocean; little to stir the imagination, and nothing to form a lasting landmark in geographical records. And yet we have been by no means idle, as I hope to show you in the course of this address. You will not regret any more than I do that our most enterprising explorers and our best practical geographers have been doing their duty as good soldiers, proving their worth in widely separated geographical fields, but with a single eye to the cause of their country—the cause of justice and right. They are coming back to us by degrees. Already the pleading of the pioneer for the support of the Society in an exploration into the depths of the dark unknown has been heard, and the sound of wings is in the air as our flying boys, thirsting for new sensations, discuss the problems of geographical aviation. If the past has been shadowed for some four years or more, there is all the brighter promise for a future full of astonishing developments; and if our geographical retrospect is at present free from the thrills and surprises which have distinguished so many of the best of the great years that have gone, we must remember that even under the most promising conditions for the work of the explorer there is but a restricted area of the world's surface to be explored. The days of sensation have very nearly passed. There are still blanks in the world's map knowledge, but not many of them, and the general outlook of the Society must now be that of solid advance in the path of geographical education and of improving much that we know but indifferently by more exact and more scientific methods of revision and reconstruction. And it is in this view of the responsibilities of our Society that it is a pleasure to

record a year of important and successful accomplishment. War-time has at length been recognized as the time when map knowledge is absolutely essential in military interests. In the wider fields of frontier and trans-frontier campaigning, as for instance over such a breadth of mountain and plain as South Africa presents, these war surveys have been chiefly geographical in character—often undertaken as an essential part of an Intelligence System. I can remember the time when, in campaigns carried out in Eastern Asia, the geographer was admitted as a sort of interloper with permission to collect scientific information for his own ends much as if he were a botanist or entomologist. The campaign was his opportunity for making a collection of maps. Only by slow degrees was it recognized that much of the success of the campaign might depend upon those maps. And so, when this war began, although it was foreseen that in Mesopotamia, at any rate, new geography and map revision was essential, and all due arrangements were made to that end by the Indian military authorities, I venture to think that never for one moment did it occur to the chief military authorities in England that geography as represented by surveying of the most rigid and exact character would be equally necessary in France and Belgium. It was soon apparent that the small detachment of special surveyors who were placed in the field for the purpose of rectifying existing maps of the gradually extending theatre of military operations on the western front, and of furnishing the military staff, especially the artillery, with the precise and accurate data which were all important in regulating the combined movement of troops and of fulfilling the difficult design of range finding for the guns, was hopelessly inadequate to deal with the work before it. Before the war was over that detachment expanded into a highly organized department numbering some 4200 employés—the most important and the best organized geographical contingent that has ever been placed in the field of a campaign. It may very well be asked how it was, in the face of the fact that the whole area of war movement had been previously surveyed on systems analogous to those of our own Ordnance Survey, and these maps, many of them elaborately contoured, were in the hands of our general staff, that such extensive resurveys were necessary? We have always been ready to credit the topographical map system of France, Belgium and Germany with an accuracy in detail at least equal to our own. War experiences have taught us that, whatever may be the value of the ordinary forms of civil mapping as applied to civil purposes, war exigencies require a far more rigorous search into topographical detail than do those of agricultural assessment. The photographs taken by our air force were with difficulty co-ordinated with the topography of the maps in use. The demand for more precise information became insistent, and as nothing really precise and exact is to be developed from an irregular or inexact basis of triangulation, the work of our geographers had to start from a geodetic beginning, so that practically completely

new maps (and new maps on very large scales) had to be evolved to meet the demand. The system adopted included little that was new beyond the application of aerial photography, which was indeed most important. Plane-tabling based on a fresh triangulation formed the basis of the work, and our flying photographers supplied a mass of topographical detail which it would have been quite impossible for the plane-tablers to secure. Perhaps the most important direct outcome of the work of our surveyors was the result as applied to artillery. Without entering into details of many technical matters which will furnish us with a large future of research, it is enough to say that our brilliant artillery service which carried us through the worst phases of the war was very largely indebted to the geographical section of the War Department for its magnificent success. This then is one of the great lessons of the war as it affects practical geography. Never probably again will an important campaign be conducted without a properly constituted geographical section. The lesson learnt in the field of the unknown, in the wide spaces of the unmapped world, has now to be applied to the field of the presumably known. War creates its own demands in almost every field, and in none more than in the field of geography.

It happened that during the progress of the interminable fighting many maps of German origin fell into our hands. This has enabled us to make some careful observations of the comparative value of German military mapping. The results of these comparisons has already been the subject of discussions which have been published in our *Journal*. No more, therefore, need be said about them than that on the whole these maps compared unfavourably with our own. We have been in the habit of giving too much credit to German enterprise and thoroughness in this as in many other fields, a credit which may possibly be due as applied to their superior Atlas cartography and the appearance of some of their finished maps, but which is certainly not due to their accuracy and usefulness as guides in the field of action.

We must look beyond Europe to find any record during last year of new geography which may add materially to the map knowledge of the world. Within the sphere of exploration which still lies open to enterprise beyond the northern and north-western borderlands of India, there is indeed little or no progress to be noted. The demands of military service are responsible for the employment of all officers who could possibly be spared from the regular course of survey duty either in the field of military action or on the plains of Mesopotamia. Here indeed, in this outlying province of Arabia, there has been a great extension of geographical mapping—all-important in the interests of future boundary settlements and the development of those great agricultural resources which may yet reproduce the fertility and the wealth of those historic lands. It is Arabia and all that concerns Arabia, from the borders of Syria to the great deserts of the south, and from Baghdad to the Red Sea, which

has been chiefly held in view in the extension of our world mapping on the scale of 1 : 1,000,000 during the last twelve months. There indeed fresh material of the very greatest interest, in view of our newly found political relations with that ancient empire, has been added to our accumulating store of geographical knowledge. Apart from that which bears more or less on matters arising from the results of this war, there have been few new explorers' tracks imprinted on the face of Asia. The borderland of Kansu and Tibet and the wild regions of the Yunnan province of China have been visited and described, and a way has been opened for further exploration of these most interesting highlands, but neither here nor in the districts of Shensi, which have also been visited by an observant geographer, can we say that there is any great acquisition of new geography, although there has been much useful correction and criticism of the old. A determined effort has been made to discover a way to the foot of Mount Everest with a view hereafter of attempting the ascent of that the highest mountain in the world, but it is still a matter for discussion and inquiry which is the most practical side for this great adventure. Although for the present it is deemed unadvisable, we anticipate that eventually no serious political objection will be raised to a purely scientific expedition which has for its object the solution of many important problems connected both with the capacity of man to exist at greater altitudes than have ever been attained, if assisted by the scientific use of oxygen, and with those atmospheric conditions which are becoming every day more important in the interests of aerial navigation.

In Africa the protracted military operations in the former German colonies have given opportunity doubtless for the collection of much useful information which we have not yet been able to collate; Southern Abyssinia too has yielded up a few fresh secrets, and we have learned new facts about that backbone of Africa adjoining the great rift valleys which furnishes some of the most beautiful and effective topography which ever gladdened the eye of the really artistic geographer. That is indeed an intensely interesting region, the value of which as a field for European enterprise has still to be in great part revealed. In America, in Canada and Brazil we are also in the position of expectation rather than of realization. Now that some of the most enterprising of our geographical explorers are free once more to respond to the call of great adventure, we may expect all the more from them as the results of more strenuous experiences. There is one part of South America which does not as a rule appeal to the geographical adventurer. Comparatively flat, often swampy, and generally unwholesome, and peopled by Indian tribes who certainly until lately regarded the European stranger much as the healthy cannibal regards his enemy in any of the most savage regions of the globe, it was not often that any stranger adventured within their reach. Here the missionary stepped in. Quietly and unobtrusively the South American Missions have pursued their Christian enterprise amongst these Chaco

Indians to the west of the great Paraná River in the very heart of the South American continent, and having found their Livingstone in the person of Mr. W. Barbrooke Grubb, they have now after years of strenuous labour opened the way to the lands and the hearts of these remarkable peoples and incidentally given us much that is of geographical value. Our Society has from the beginning been deeply indebted to missionary enterprise for its knowledge of the deep recesses of the inhabited world. We have always been glad to honour those brave men who take their lives in their hands, just as surely as any good soldier, and seek out the lost souls of humanity. This Chaco enterprise is one of the greatest of South American missionary triumphs, for it is indeed a triumph, and we may, I trust, look forward to a detailed account of the geographical issues involved in it from Mr. Grubb himself. Meanwhile I can only record the fact that whilst war has been raging and destroying the very roots of civilization in Europe, the first early seeds have already been sown in some of the darkest lands of South America by the faithful and courageous efforts of our men of peace.

As the years roll on we shall inevitably see a redistribution of humanity (civilized white and coloured humanity) throughout the less densely populated regions of the globe—in short, there must be a sort of boom in emigration. This matter of emigration is so important to the British Empire both at home and overseas that the closer geographical acquaintance that we can make with the unexamined outlying regions that may be open to immigrant occupation the better. This is obviously one of the most important functions of our Society. We do not yet know all that Africa may have to offer to the white emigrant, although we may have a shrewd idea that beyond the colonies already open to us there is very little left available for European enterprise, and that little lies in the highlands which cradle the sources of the Congo, the Zambezi, and the Nile. It is no longer the width and breadth of the open and available spaces which concern us chiefly. These no doubt are great. It is the quality and opportunity for development as pasture or agriculture which is important and to which the attention of geographers is now specially directed. Canada and Australia may be still open to immigrants, but never again will either Canada or Australia commit herself to a welcome for any but first-class, A1, applicants for enrolment in their rising nationalities. Unfortunately England is over-burdened already with a population of which the greater part is not A1; so that we stand on the slopes of a slippery decline. We may indeed lose the best of our people without adequate compensation.

In the East as in the West—in India as in England—we have fostered the unlimited increase of a population that adds nothing to the strength of the Empire, but much to its political difficulties. Fortunately the open geographical fields for the absorption of the Indian are easily recognizable and already well tried. East Africa has proved to be capable of furnishing

an environment in which the native of India can live and flourish as successfully as did the Arab of old. The organization of the German colony opens out a large vista of useful opportunity for native occupation, when indeed the extent of territory that is really suitable for European life is very much restricted. For more centuries than we can tell, East Africa has looked further East for the dominating elements amongst her peoples. There is nothing new in the irruption of Arab or Indian. All that is new is the imposition of a just and humane government which will treat all classes of natives alike. Mesopotamia again is another field of which it may be said that Indian military occupation is a necessity for the immediate future. And there can be little doubt that in the further future military occupation and a settled and just government will lead to the renewal of an understanding between the Muhammadan peoples of Arabia and India, such as we read of in the Arab records of the past, which will be a real source of strength to the Empire. Much indeed still remains to be said in the geographical view of this all-important question of emigration, but time is short and there are other considerations before us.

Chief amongst them perhaps is the subject of Geographical Education. Is there any real awakening to the importance of geographical knowledge in every department of the State or in the interests of commercial developments? Does the public, which has depended largely of late years on the outline maps reproduced in our daily papers for a reasonable understanding of the course of the war and the direction of military action, appreciate the fact that war purposes (to which we have already referred) are not the only or indeed the most important of public functions demanding geographical enlightenment. There is unfortunately too much apathy on this very vital subject still existing. Our Society and the Geographical Association have worked together to improve the position of Geography as a subject of instruction in the Universities and Schools of the country, and have made joint representations to the Board of Education. We cannot complain either of want of sympathetic interest on the part of the Board, although it must be admitted that the position of geographical work in the advanced courses regulations for secondary schools is still very unsatisfactory; and we have undoubtedly received great encouragement from the universities which have responded to the call by making Geography an Honours subject in their examinations. All this is useful and progressive, but in my opinion there is still a want of appreciation of the value of geographical instruction both by the public and by secondary school teachers. Geography has to take its place in the competition for a due allotment of time for instruction which can be afforded in the general curriculum of scientific study, and the competition is severe. It is idle to expect a demand for instruction on the part of students unless the practical value of it can be demonstrated by teachers. Unfortunately geographical knowledge does not lead to direct employment, which is what the great majority of students look to, and it is only by a far-sighted

appreciation of its ultimate necessity if England is to hold her own in the world of commerce, and not by the immediate advantage gained by the allotment of more or less marks in the civil service examinations, that the importance of geographical education can be assessed. There have doubtless been other reasons for the general depreciation of geography. One of our ablest exponents of the subject (Mr. H. J. Mackinder) writes as follows, and I make no apology for quoting some of his remarks: "In this country we value the moral side of education, and it is perhaps intuitively that we have neglected materialistic geography. Before the war not a few teachers, within my knowledge, objected to geography as a subject of education on the ground that it tended to promote Imperialism, just as they objected to physical drill because it tended to militarism." The war and the rough knowledge which it has implanted on our "mental relief map" through the agency of newspapers have, however, to a certain extent introduced new modes of thought, and "important geographical names such as Berlin, Bagdad, Herat and Pekin are no longer mere words but definite centres of the world's activities having a recognized relation one to another." "But the Prussian (as Mackinder reminds us) and his father and his grandfather have debated such concepts all their lives, pencil in hand. . . . In arranging the detailed terms of peace our statesmen will no doubt have the advice of excellent geographical experts, but the German representatives will have behind them not merely a few experts but a great geographically instructed public, long familiar with every important aspect of the questions as they arise, and quick to give a far-sighted support to their leaders. This may easily become a decisive advantage." This is all very true, but we must remember that the comparative isolation which has been drawn round England (and yet more round America) by geographical position in the world has much to answer for in the intuitive want of interest shown in the geography of countries divided from us by the seas. We have to reckon with this now, and it is up to every geographer present who has any educational interest to do his best to support the efforts of the Society to bring about a more general appreciation of the necessity for geographical study.

During the year under review there has been a close alliance between the Society and the geographical department of the War Office, which I think we may claim to have been of great mutual advantage. A great part of the Society's house has been given up to war work, and in the absence of many of our regular staff we have been fortunate in securing the services of some most efficient voluntary workers (including several ladies), who have nobly given their time and their talents to the cause of maintaining a high standard of map support for the ever-increasing demands of political and military service.

The preparation of an international map on the scale of 1 : 1,000,000 had been in progress for some time when the war broke out, and its obvious usefulness for general international purposes during the war called

for increased efforts in its production. Commencing with the compilation of six sheets of Central Europe to be reproduced by the Ordnance Survey for the General Staff, the output rapidly expanded into about ninety sheets during the four years of the Society's war work, covering nearly all Europe and extending through Asia Minor and Mesopotamia to Persia, as well as a considerable area of Northern Arabia. This has not been treated as a confidential map. It is within reach of the public by purchase. It has proved most valuable in the discussions of such general questions as dealt with communications, strategy and politics, not only for purposes of the General Staff but eventually at the tables of the Peace Conference. It has lately been decided to make use of this map as indispensable for the work of international boundary delimitation by all the Powers. It is gratifying testimony to the value of the map that it should have been so universally accepted as the best general map in existence. But whilst war business in Europe and Asia has occupied our attention chiefly during these late strenuous years, the great necessity of map-making in Africa has not been overlooked, though the extent and the value of original material from which to compile the maps of Africa are nothing like so great or so good as that which furnished the basis of the European maps. Consequently the scale of reproduction for Africa has been reduced to 1 : 2,000,000. Fourteen sheets have been fair drawn covering Central Africa, and we may hope soon to make use of them. There is also a beginning made to a general map of Asia on the 1 : 5,000,000 scale. All this mapping on geographical scales has been the chief business of the Society during the last two years, but this by no means includes the full sum of its activities during that period. The reduction of photographs taken from the aeroplane to map-making purposes gave rise to some experimental work in order to meet the difficulties due to errors arising from the want of parallelism between the planes of the camera and the horizon ; the methods are being thoroughly investigated and the errors eliminated, but the co-ordination of aerial mapping with the ordinary processes of surveying is still in a process of development. It is gratifying to note that the Army Council has thanked the Society for the work performed, and particularly refers to the value of the 1 : 1,000,000 map.

The library and map collections have been indented on continually by almost every department of State, and have on the whole met the demands made upon their resources successfully. The library has been yearly increased in extent by works either purchased or presented to the Society, and many valuable additions have been made to the map collection. I might mention especially the gifts of Mr. Yates Thompson, who has more than once presented us with most valuable records. In spite of the fact that by the change of quarters from Savile Row to Lowther Lodge, a great increase in space was attained both for library purposes and for the storage of maps, our available room is so rapidly diminishing that we must look to the erection of that much-wanted Hall to meet our increasing

demands. Indeed, it will eventually become a question of limiting our possessions in both directions if we do not mean to expand into a museum. We can however maintain with confidence that as it stands at present our library, under the fostering care of Mr. E. Heawood, is the best geographical library in the country.

Our evening meetings have been well attended, and I think that we may claim to have secured a useful and varied series of addresses. Dealing first with the end of last session, after the last Anniversary meeting: we had early in June Sir Alfred Sharpe's description of the "backbone of Africa," which will always rank as a masterly paper by a master mind. Perhaps the most successful and attractive lecture of the season was that by Mr. Meighen on Canada. It is not often that we can secure such a distinguished exponent of his subject or one with so complete an administrative knowledge of it. I regard Mr. Meighen's contribution to our records as one of permanent value. And I would recall to your attention several papers which were contributed to our *Journal*, though not read at our meetings: notably those by Mr. Kingdon Ward, who possesses very exceptional knowledge of one of the most interesting and difficult corners of the Salwin country on the Yunnan–Tibet frontier; by Mr. Carruthers, who embodied some of the results of his long study of Arabia in his paper on the "Great Desert Caravan Route"; and by Colonel Pirrie, who came to us fresh from the superintendence of surveys in Mesopotamia. Lectures on the districts between Baghdad and Baku by Colonel G. Napier and on Arabia more recently by Mr. Philby (the latter an excellent geographical paper on a bold journey through country never before visited by a European) have added much important information to our knowledge of those regions in Asia which are immediately contiguous to Mesopotamia and which must surely hereafter be included within the pale of Indian politics. We have, in addition to these subjects of discussion in the remaking of Eastern frontiers, a paper on Transylvania from Dr. James Berry, and an address by Commander Roncagli of the Royal Italian Navy on the strategic position of Italy in the Adriatic, both of which must rank as of most material value in these days of international resettlement, for both authors were probably the best exponents of the theme of these addresses that could possibly be found. The paper on "Eastern Tibet" by Mr. Oliver Coales was a valuable addition to our knowledge of country still singularly unvisited. A new view of some of the unknown parts of Southern Abyssinia by Mr. Arnold Hodson was much appreciated, and a very careful summary of the position of Spitsbergen and its commercial and strategic value to England by our Vice-President Sir Martin Conway was an important contribution to the subject-matter of much popular discussion. Miss Czaplicka, on Poland, gave us an address of exceptional interest distinguished by a comprehensive knowledge of the subject which could hardly have been acquired by any one not of Polish nationality.

The subjects selected for our evening meetings have usually had reference to passing events of public interest, and we have endeavoured as far as possible to secure the services of ladies and gentlemen as lecturers who have been actively and directly interested in the scenes and events they describe. Colonel Winterbotham's evening lecture on the subject of geography at the front was one of the most striking of the Session. Similarly with the Research Meetings held in the afternoon: our discussions have ranged round matters of scientific interest bearing on questions which have often been in close relation with war experiences. Mr. Hinks, our Secretary, has devoted much time to the critical examination of such German maps of the war theatre as have fallen into our hands from time to time, and his address at one of these meetings which dealt with the comparative values of English and German map-making was most enlightening and led to those conclusions to which I have already referred. Colonel Winterbotham and Colonel MacLeod have contributed most valuable addresses on the subject of survey and air photography in war. This matter of air photography may be said to await development. It is at present in its infancy, although even in these early stages it has proved of immense service in the mapping incident to a campaign. As an adjunct to the processes of regular survey it is already invaluable, but it possesses the deficiency of incapacity to measure relief, or the differential values in altitude between the hills and the plains, and consequently can only be regarded as an adjunct to be carefully co-ordinated with positions otherwise fixed on the Earth's surface. This deficiency does not seem to be irremediable by any means. I have like doubt that it will be successfully dealt with ere long. But there is a far wider future before the aeroplane than any which lies in the restricted area of a campaign. One of the most interesting discussions of the day is the future of the aeroplane in geography. It is doubtful whether much can be made of it in very high altitudes, amidst the peaks and crests of great mountain systems. Air currents are too irregular and clouds too persistent. I cannot but view with some misgiving the application of the system of air-reconnaissance to Arctic and Antarctic regions. In the Arctic there is the prevailing difficulty of hummocky ice and indefinite possibilities of landing, and in the Antarctic we know that the meteorological conditions are as a rule most unfavourable. But over vast wide spaces of unexplored territory such as may be found in the desert regions of Arabia or the widespread forests and uplands of Africa or South America I can imagine nothing more effective and useful. To be able to look down on a forest, to note the thin spaces or lines indicating paths or rivers instead of waiting months in the twilight shadows of the trees hacking a difficult way through almost impenetrable bush seems to be an almost ideal method of dealing with a special form of geographical reconnaissance. I need hardly say that this Society does not welcome propositions with regard to long-distance flights. If there is no geogra-

phical problem to be worked out or no geographical information to be obtained, the proposition is not likely to be entertained by us. Long-distance flying belongs altogether to another sphere.

Turning to matters of domestic interest, I regret that no very immediate promise of restoring the *Journal* to its pre-war dimensions can be made. It is, as you are probably well aware, owing to the excessive cost of paper and of printing that the *Journal* has been reduced in size. Setting aside its attenuated dimensions, I think you will agree that the quality of the matter contained in the *Journal* has been kept fully up to the standard of previous years, and that the illustrations have been exceptionally good. In the able hands of our Secretary, as Editor, we may rest assured that the best will be made of the material, literary and otherwise, which can be made available for it. I should like especially to record my appreciation of the contributions which are received from our learned librarian Mr. Edward Heawood. Through him the Society learns the value of many of the old historical maps or publications which find their way to the library; and the geographical researches of Mr. Heawood undoubtedly give a value to the *Journal* which is not merely exceptional but almost unique.

You will wish to know something of the position of the Society in respect to its extension by the acquirement of a Hall which will render it independent of the rather inferior accommodation which is to be found in the Burlington Gardens theatre or elsewhere. The negotiations which were pending in the matter of the sale of a part of the Lowther Lodge Estate (which you will remember was always anticipated when residence was changed from Savile Row to Kensington) were interrupted by the war. Now, however, that they can be resumed, it is satisfactory to be able to state that there seems to be a fair prospect of completing a deal. We shall, however, have to face a financial position which will be very different indeed to that which obtained before the war. Then we reckoned that for the sum of £25,000 we could obtain all that we really wanted. The cost of building in these days has increased by 100 to 150 per cent., and although the cost of material may become less the cost of labour does not seem likely to diminish appreciably, and we must surely look to a very considerable increase in our original estimates which may require special measures to meet. Above all things we desire to add to or include with the Hall some memorial of those of our number who have fallen in the war. Possibly this memorial may take the form of a special gallery for exhibition purposes, but it is a matter which requires further careful consideration in connection especially with our financial outlook.

Regarding the Staff of the Society, it is pleasant to record that we have the majority (four out of seven) of those members back again who were with us when called away to military duty. Their places have been filled by capable substitutes, and our war-work has been largely in the hands of those most excellent amateurs to whose work I have already referred and

who have been recognized by the Society as Honorary members, but none the less we are glad to secure once again the original members of the Staff who were so thoroughly efficient in pre-war days. This being nearly my last opportunity of addressing you from the President's Chair, I feel that I must record my high appreciation of the ability and steady devotion to duty which have been shown by Mr. Hinks the Secretary, Mr. Heawood the Librarian, and Mr. Reeves the Map Curator and Survey Instructor, and offer my thanks not only to them but to all the members of the R.G.S. Staff who have assisted me so cordially during my term of office as President.

It would be a mistake to say that the Society has suffered nothing in regard to its very distinguished list of membership during the war. We have lost many old friends and good geographers, whose names have been recorded from time to time, and the Society is not the same without them. But as regards totals, we have not lost very much in membership, as the report now circulated will show you. Financially we are in a much sounder and stronger position than we could well have expected. We have reason to congratulate ourselves that we have not only contributed most materially towards some of the most urgent and important needs of the General Staff during the war, but that we have come out of it constitutionally sound and on a footing of cordial recognition of our usefulness by Government. In short, the war has enhanced our reputation as a working Society. There is nothing more for me to add than to ask for your confidence in those Members of Council for whom you will vote to-day whose names you can recognize in the lists before you. They are all distinguished men. I regret that we have not been able to secure the services of our Gold Medalist, Colonel Jack, on the Council owing to certain official difficulties. As for my proposed successor as President, Sir Francis Younghusband, he is such an old friend of the Society, and his record as a geographer stands so high, that I feel that it would be an impertinence on my part to make any pretence at an introduction. May the Society never want a geographer so able and so distinguished to lead its councils and preside at its meetings.

GEOGRAPHICAL WORK WITH THE ARMY IN FRANCE

Lieut.-Colonel H. S. L. Winterbotham, C.M.G., D.S.O., R.E.

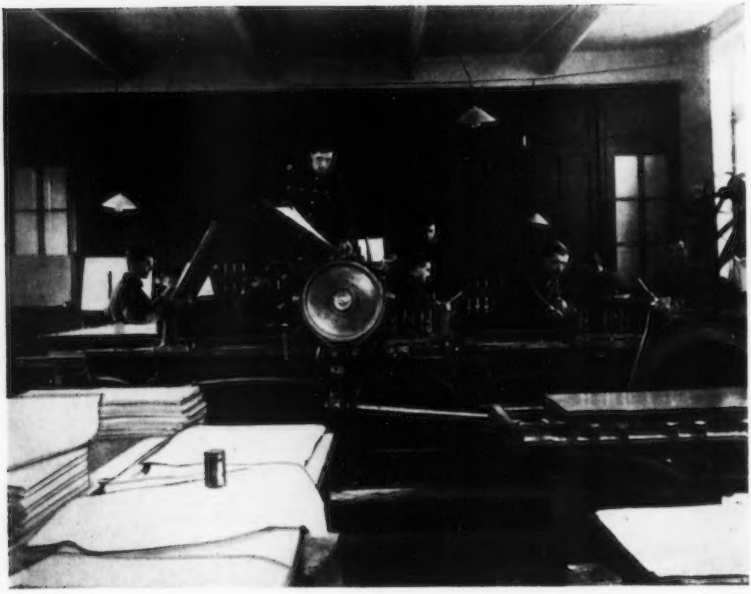
Read at the Meeting of the Society, 24 February 1919.

IN the early days of the war the surveyor had no chance of exercising his profession. All that he could do was to issue such maps as had been published if he could find the people who wanted them in time. Even this proved exceedingly difficult, and Colonel Jack, who was our

1. TRIG. OBSERVERS WITH HELIOGRAPH

2. TRIANGULATION WITH LUCAS SIGNALLING LAMP

3. GERMAN TRIG. SIGNAL OCCUPIED BY BRITISH SURVEYOR AFTER AN ADVANCE



4. PRINTING OFFICE OF A FIELD SURVEY BATTALION

chief throughout, with his small band of assistants had a very trying time in consequence. After the opening battles in Flanders the line became more or less stationary, and the advent of "Granny," the first 9·2-inch howitzer, quickly followed by others of her kind, gave us our first ideas as to what tasks would fall to our lot. The battery commanders naturally complained of the map, which at that time was only an enlargement of the French 1/80,000—and neither better nor worse than the original. Trench systems were already becoming very intricate, and there were numbers of other concealed targets, such as gun or battery positions, and ammunition dumps to engage. A better map was called for imperatively, and as such a map did not exist, we had to make one and to show on it the German trenches, dugouts, battery positions, railways, and new roads, as they were made.

Next, as even the best maps have errors, we began to survey the positions of our own heavy guns and make carefully prepared battery boards or charts for each gun, on which were shown the position of the gun and the area over which it had to shoot. Finally, the most interesting subject we had to deal with arose with the difficulty of locating the German guns. As time went on these were more and more carefully concealed. Woods, houses, and villages all hid a certain proportion; and the professional camouflage expert did his best for the remainder. Before any big attack it was essential to silence these guns and to prevent them from firing on our own advancing infantry. For this purpose every European army has developed two methods of accurately locating the guns employed by the enemy.

The first of these methods is straightforward triangulation of the flash of discharge. The flash of discharge appears by daylight as a bright spot of light and at night as a semicircular glow. If the gun is behind cover or in a valley, one can still see this glow and take a bearing on what appears to be the centre of it. The other method is sound ranging: a new and fascinating branch of survey which was born in this war and which has obtained a great deal of success.

The main tasks we had to perform, therefore, were: (1) The making of the map; (2) Battery survey; (3) Location of the enemy's batteries; and these I will try and illustrate to you to-night.

To deal with these various matters, we had in the autumn of 1914 about ten officers and men all told: towards the close of the war we had between four and five thousand. Of these about a third were experts in the ordinary survey trades, and about two-thirds (those employed on flash spotting and sound ranging) were schoolmasters, engineers, architects, and professional people generally.

1. **The Making of the Map.**—There is no published large-scale map of France except the Fortress *plans directeurs*. These cover a relatively very small area and have been of little value to the British Army. Our

first task was to map the area in which operations were actually taking place. The new survey was ultimately extended over the whole of North-East France and covered about 12,000 square miles.

In making a map of any large area it is essential to start from a good framework of triangulation. Fortunately such a framework exists in most civilized countries, and we were able to procure full information about the French and Belgian triangulations. We were confronted however with rather unforeseen difficulties in using these triangulations. The original French national triangulation, which is contemporaneous with our own, was partially reobserved and recomputed in 1900. In addition to these two national triangulations there is a good French Admiralty coastal triangulation, and finally, connecting France and Belgium, an international arc of parallel in which observers from the Ordnance Survey took part. In one or other system of triangulation most of the churches, windmills and outstanding features of the area of operations were fixed, but in order to make the best use of the material, all these systems had to be connected up to each other so that one could pass from one to the other with safety.

We began to map in February 1915. Even by that time, however, many of the churches whose positions we knew had been knocked down. We had to start at once, therefore, amplifying and patching the original triangulation. Our observers, from that time onwards, worked continually up and down the front, but it took some little time before the British Army grew accustomed to seeing a soldier equipped with a theodolite. The first observer to go to work was arrested as a spy by a zealous ammunition column. Acrimonious correspondence followed, in which the A.P.M. took a hand, before he was released. Our triangulation was done with a 5-inch Troughton & Simms micrometer-microscope theodolite.

The weather was the trig. observer's worst enemy. Probably none will carry away with him pleasant recollections of the weather in Flanders, but assuredly if he does he will not have been a surveyor. Such fine spells as we did have were spoilt by clouds of dust from constant traffic. It was seldom that one could observe long rays without recourse either to the heliograph (Fig. 1) or to the Lucas signalling lamp (Fig. 2). The latter is peculiarly useful on dark days and at night.

Along the larger portion of the British Front good views of the area in German occupation could be obtained from places well behind our own lines. In certain spots the only view obtainable was from some point in our own trenches. For such cases we had small periscopic theodolites which were most valuable, for any observer with an instrument, whether he be a gunner officer with a director or a trig. observer with his theodolite, who "sets up" in full view of the enemy's trenches is almost bound to draw fire.

Our difficulties varied of course very much with the type of country. In the open rolling downs of Picardy and Artois there are wide views

and few difficulties when visibility is good; but on the other hand there are few conspicuous features to fix, and the churches lie mostly in the hollows. The worst stretch of country we had to deal with is that lying between Bethune and Armentières, where there are quantities of high trees in a dead flat plain.

In Italy, of course, conditions were well-nigh perfect. Standing on the edge of the Asiago plateau one might count the trig. points in the Venetian plain by the hundred, whilst the Italian records are exceedingly ample and simple to understand.

The most important area for mapping and for survey generally is the actual area of operations, extending from the heaviest and furthest back English gun to its German "opposite number." In this area, however, both artilleries are busy destroying all points of vantage. Stations have to be selected with great care. What is the highest and most conspicuous point of a building to-day will probably not be so to-morrow, and if a ground station is made, the signal marking it must not be so conspicuous as to draw fire. On the other hand, unless it is solidly built and looks as if it were really fulfilling a useful purpose it will be taken at once for some one's fire. We tried to fix, by intersection, all recognizable objects visible in the German lines in order to be able to push the triangulation forward quickly if the line advanced. Here again, however, the preliminary bombardment generally spoilt our plans by knocking down everything we had observed upon. Roeux Chemical Works, the scene of such bitter fighting in 1917, provides an excellent instance. We had many points fixed there, chimneys, gable-ends, and the like, all of which were smashed to atoms by our own gunners before our advance.

Fortunately for us the Germans made excellent trig. signals. Stoutly built, and with four legs, they survived a lot of shelling, and although of wood, must have been regarded with much more respect than they would have been in the British Army, for as we advanced we found them on most prominent features and in such numbers that few can have been missing. Fig. 3 shows one of these signals with a British observer underneath. This particular signal near Pozières was most useful, for it could be connected up, immediately, to our triangulation west of the Ancre, and from it an excellent view extended eastwards towards Bapaume.

Some of the German signals, probably one per corps area, were specially built to a height of about 60 feet. On the top was a small observer's cage immediately under a pointed beacon, but the signal itself was constructed more as an aiming point for the guns of the corps than as a station for the surveyor.

The framework of fixed points being now complete, the detail of roads, villages, etc., remains to be added. Naturally the area within our own lines could be surveyed on the plane-table, and indeed large areas were mapped in this way. To continue the map over Germany territory some other means had to be devised. Fortunately in the early days of

the French Revolution a survey was made for revenue purposes. The whole country was surveyed by local surveyors on the scale of 1/2500. The resulting map was never published, like our own, but remained in manuscript and in small and irregular pieces. Some are excellent work, but they are not all good, and the fitting of the various plans together has to be done with care. The originals are kept at the capital of each province in the Revenue office. We were fortunate enough to recover most of the plans of the "Pas de Calais" from Arras, where they had been put in a cellar when the bombardment of Arras began. In 1900 the then French Government decided to resurvey the whole country and make new cadastral plans. Unfortunately lack of money caused the project to be given up.

All those plans which we used, therefore, were a century out of date. We found it easier and more accurate to compile the plans on a framework of road junctions than on plotted trig. points, because it is not always easy to recognize the exact site of a church spire or tower on the original plans. The framework of road junctions was easily obtained on the plane-table.

The map is next compiled as explained above, and now it must be brought up to date. The French country village appears to change very little. Houses, property boundaries, streams, ditches, etc., remain practically the same as they were in Napoleon's time; but main roads have been straightened and improved. Where industries have arisen there is, of course, a very great development in the past century.

Now to embody all these alterations would have been extraordinarily difficult in the time available had it not been for the development in aerial photography. Photographs taken vertically from an aeroplane supplied the information wanted, not only for the improvements and additions to the planimetry but also for mapping the trenches. They were in fact a diary of German doings. One could identify on them all sorts of defensive works from the wire in front of the trenches to the airline telephone system.

Those photographs were of course liable to distortion due to the camera not being vertical at the moment of exposure. Care had therefore to be exercised in the plotting. We did at first make use of the camera lucida. It is very easy to get an approximate fit of the air photograph on the map by this means, but most difficult to ensure a really accurate one. Generally then we made use of the principle that straight lines on the ground remain straight lines on the photograph, and fixed points by intersection on the photograph, using the proportional compass within narrow limits only.

The best method however is to rephotograph on a movable easel from the original negative. By identifying on the photograph a certain number of points whose positions are known and plotting those positions on a piece of paper which is pinned to the easel, it is possible to arrive at the

correct angle at which to rephotograph. Draughtsmen can then be given a copy correct to scale and shape. The detail of the map was now fair drawn for printing, and the maps we ultimately provided were of a really high order. Compared with first enlargements from the 1/80,000 the difference is peculiarly marked, and show errors in these originals of anything up to 300 yards.

So far we have dealt only with the planimetry. Contours are of course of great importance also. The contours on the 1/80,000 map are necessarily very generalized and when enlarged to 1/20,000 bear little resemblance to the ground. Our contours were all referred to the comparatively modern and excellent levelling of France. The bench-marks of this system were plotted on the first compilation of the map before its revision with air photographs, and the work was then transferred to plane-tables. Contours were then surveyed on the ground. One might have supposed that captured German maps would have proved very useful in contouring. This was not the case, however, and it appears to have been the exception with them, and not the rule, to survey con tours with any care.

The finished map was then used as a background for many different editions showing the information wanted by the different arms and services. The most important were the trench, enemy organization and counter battery editions.

Each corps had its own Corps Topographical Section which issued special duplicator maps. They were able in this way to send out information quicker than could be done by the Army. The detail of the map was taken direct from the Army map and special early intelligence items overprinted.

It is interesting to compare our own maps with those produced by the Germans. The latter always declined to go into detail on the plea that it was not of military importance and "savoured too much of erudition" ("schmeckt nach wissenschaft"), but in practice it is obvious that for the proper placing of batteries every hedge and field must be shown.

The French mapped in great detail and had the advantage of clearness, for their conventional signs are perhaps more logical and certainly neater than some of our own.

Throughout the war the bulk of the map reproduction and printing was done by the Ordnance Survey. Over thirty-two million maps were printed and sent to France from England. Later in the war an overseas Branch of the Ordnance Survey was established in France, and took over the printing of large-scale maps.

In the early days Field Survey Battalions had no printing machinery except hand presses. The Battle of the Somme taught us, however, that it was vital to be able to print at every Headquarters and to issue information a few hours after each successive advance. Every Field Survey Battalion was given two printing machines capable of turning

out seven hundred copies or so per hour in one colour. These machines printed a map 35 by 22½ inches. Once installed the difficulty was to allow them a minute's rest. During operations they were always working round the clock, and any delay or hitch would result in a period of intense activity to catch up with lost time. The machines are cumbrous and very heavy. During the spring battles of 1918 we lost one, although we left it in an unworkable state, and we ourselves captured several German machines.

Special beds had to be made for them, and engines, shafting, and pulleys put up. When an Army Headquarters moved a string of some thirty lorries would be started off with all the gear, and it would be three or four days, even with previous arrangement at the new Headquarters, before an exhausted and unshaven printing officer would report that all was well. Zinc plates were prepared by the wet-plate process, and each battalion had its own camera and accessories.

Now having printed the maps the question of map issues follows. The ordinary scale of issue for the type of stationary trench warfare we were so familiar with was known to all, and no great difficulties arose. Curiously enough the chief difficulty was to persuade people to ask for enough. A map should be replaced whenever it has become illegible or torn. Many a wet day's work deserves a map all to itself, but many officers and many units persisted in regarding a map as an article which could not be replaced without incurring the risk of a reprimand. Then too on special occasions there was often no time to consult the troops, and a judgment had to be made as to what they actually did want both in type and in number.

Every day the "Maps" cars started out on their rounds to Corps and Divisional Headquarters, and occasionally to special units who were particularly short of maps. The day's run might be anything from 40 to 100 miles, and during operations the various Headquarters might, one or all, during the day move to a new location.

There was too, ever present, the fear of some accident which would result in the loss of a car until a new one could be supplied. Considering the class of roads we had to follow, ordinary accidents were not common, but they occurred, of course, much more frequently than would be the case in peace. In addition we lost two from shell fire and one crushed by a falling tree.

2. **Battery Survey.**—Obviously in order to measure the map range and bearing from his directing gun to his target, the gunner wants to know the correct positions of both. In past wars no special provision was made for such surveys in the field, for targets were mostly visible and gunner officers were trained in all that was necessary. Nevertheless the principle of employing surveyors is by no means new, for all coast defence batteries have been surveyed for many years by the Ordnance Survey.

Gradually during the course of this war each army has introduced some special system of battery survey.

The map itself is not sufficiently accurate to fulfil the purpose. It is impossible to prevent errors of 20 to 30 yards in hastily prepared maps. And if the element of surprise is essential, or in other words if the target must be hit without previous registration, careful preparation must be made and the gun aligned along that bearing which will bring the trajectory over the target.

Battery survey therefore includes the survey of the directing gun, the provision of an accurate bearing from either the gunsight or a special bearing picket to some recognizable reference point, and the preparation of an artillery board. The latter is nothing but a chart of the gun position and its sector of activity mounted on a flat surface which is unaffected by changes of temperature and humidity, and showing correctly the position of the gun and of all known points in the sector. Tens of thousands of these boards were issued, and it is very curious to find out that their use began more or less simultaneously in British, French, and German Armies.

The survey of the directing gun is not without its difficulties. In choosing the position the gunner is influenced largely by his desire for concealment. He may hide his battery in an old building, or in a wood, or in a hedge—wherever it is, it is hardly ever in the position a surveyor would choose for his work. On occasions, indeed, a survey in the time at our disposal was impossible, and positions were fixed from air photographs, while the surveyor secured an accurate bearing for the gunner from observations on sun or star. The accuracy required is not of course equivalent to that one aims at in the ruling triangulation. A small portable theodolite was generally used therefore, and the position fixed by resection.

Bearing pickets were surveyed near all likely battery areas. A small printed notice left at each picket gave details of its position and the bearings from it to surrounding prominent objects. Survey in our battery area necessarily implies working in the enemy's counter battery area. Each side resented any such performance, and whilst our gunners were fortunate in chasing away the German observers and causing them many casualties, we also were occasionally compelled to desert our instruments in rather a hurry. Fig. 6 shows a couple of our observers resecting near a bearing picket which can be seen on the top of the mound. One of the observers is searching the horizon for a trig. signal which has so far eluded him. It is not possible nor is it nearly so important to survey the position of field guns with a theodolite. A graphic resection is generally enough. It is interesting to note that in all cases the position finally determined by resection is independent of the map, and is part of the skeleton of fixed points to which everything is ultimately referred.

3. Location of Hostile Batteries.—It is curious that sound ranging and flash spotting should have grown up under the organization known as "Maps," because as a matter of fact they are the very units whose results do not depend at all upon the map. The aeroplane observer and the observer in a balloon can only say where they judge a flash to have been on the map. The sound ranger and flash spotter work from surveyed posts or bases whose position is found from the trig. points. Their results are, as a matter of fact, more reliable than any others we have had.

Sound ranging had been thought of in Austria before the war, although I understand that it was long before they made much practical use of it. The French had at least five practical methods well advanced in January 1915, and we chose one of those systems in May and got the first section going in September. We were fortunate in having some first-class officers of the New Army who had all the necessary technical qualifications, and we can afford to say that it was not long before we led all competitors.

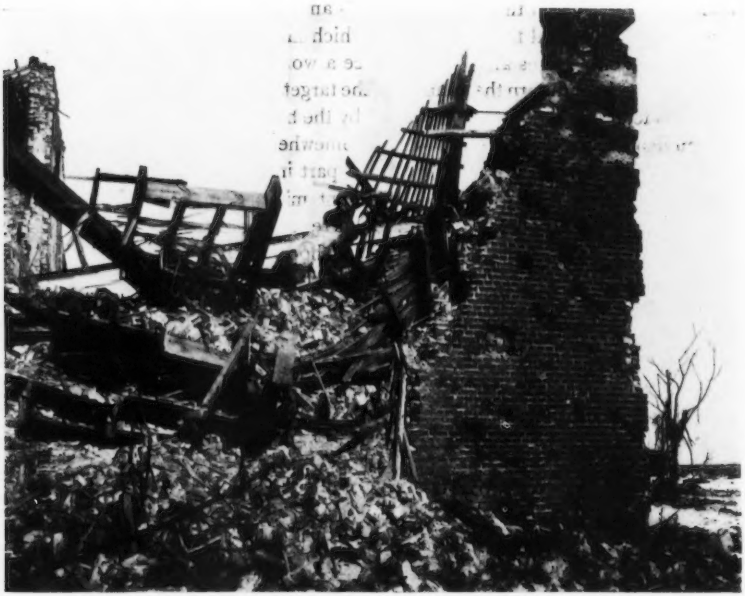
The theory of sound ranging is very simple. A number of microphones, usually six, are distributed along and roughly parallel to the front, covering 8000 or 9000 yards. These microphones are connected to an instrument at headquarters which records electrically the exact time at which the sound of a gun report reaches each microphone. If this sound reaches two microphones simultaneously the gun must be equally distant from them both. If it reaches A sooner than B it must be nearer to A than to B, and as the intervals of time between each pair are accurately determined it is a mere matter of mathematics to calculate in which direction relative to A and B the gun must lie. Three microphones should be enough to determine a position. We used six so as to ensure having ample verification. The time intervals are measured from a photographic film. This film starts to move, ready to record the arrival of the electrical impulses from the microphones, at the discretion of a "forward observer" who is somewhere well in front of the microphones. The film is ready and developed a few seconds after the sound has reached the microphone, and is passed to the officer who plots the results. This is a very quick and easy process, for the plotting boards are so made that the final position can be determined very quickly. Skill and practice are wanted in reading the film, in being certain which point to choose as the exact moment of the "break," and in making the due allowances for wind and temperature.

Sound ranging depends very largely of course on atmospheric conditions. If the wind blows from the microphones towards the gun the sound is prevented from reaching them, and in such cases no results can be obtained. Sudden changes of temperature are also a trouble; and there occur times during our own bombardment when firing is so continuous that even that minute interval which must separate noise from noise, if it

5. DISTRIBUTION OF MAPS BY CAR

6. FIXING BEARING PICKET BY RESECTION

7. FIRST ESTABLISHMENT OF FLASH-SPOTTING POST IN TRENCH AFTER AN ADVANCE



8. FLASH-SPOTTING POST IN RUINED BUILDING

is to be distinguished on the film, is not available. On the other hand sound ranging is not hampered by fog or by darkness, nor by any cover, artificial or natural, which may hide the offending gun. The results often exceeded fifty locations a day, and, in the main, were exceedingly accurate.

Flash spotting is a very old and well-known method of locating hostile guns. Long before this war cross-observation was practised, and siege observers were well trained. Nevertheless, nothing was effected on the Western Front until such observation was organized as the duty of a separate and independent unit. The first flash-spotting unit was raised in 1915 and was called the Artillery Survey Detachment. In mobile warfare posts are pushed forward and established in trenches or hurriedly dug in pits. The positions are then resected and instruments set up. The instrument used for observation was a combination of the French telescope called the "longue vue à prismes," and a British base. The telescope, an excellent optical instrument, had eyepieces of three different powers, so that the observer could watch movem of troops, or of trains, at long ranges in clear weather, or a trench clo hand in misty weather. A special little prismatic glass giving very little magnification but a wide field of view was used at night.

A flash-spotting observer had one of the most interesting tasks of the war. At one moment he might be watching a distant train, and deciding whether it agreed with the usual daily progr ame or whether it was part of a special and unusual train movement w might be useful evidence to the staff. Ten minutes after he might se rking party repairing some German trench, and wa the gunners of t fortune was offering them. Then his telephonist might be called up headquarters with the information that a German battery was active sc re in Square M 35 *d*, and he must search till he finds it and take his n establishing its position. Then a battery commander new to that fron might arrive and want to be shown the landscape he is to shoot over. H would want to identify each conspicuous feature, or, if his duty were to s t at trenches, every trench junction and belt of wire he could see.

An additional interest is due to the fact that each side is always on the watch to detect observing stations, and that an observer may expect to be shelled out of the post if he or any careless visitor betrays the position of the post by unduly exposing himself to view. In posts close to the line it was usual to observe through black masks. When time permits, posts are better dug in and made as comfortable as possible. Each observer wears a telephone headpiece and a breastplate transmitter, and has a telephonist sitting next to him. The bearing to his R.O.s and a map of his area of observation are put up on the wall at his side. In rolling open country such a post gives as much view as is wanted, but in close country like Flanders it is a great advantage to observe from as great a height as possible. In such cases the O.P. is put in a house or building

of any sort, in a camouflaged tree, or in special towers. Of these alternatives a ruined house is the commonest. Here one finds concealment, though protected neither from weather nor shell fire.

The most important factor of success is the training in "concentration" on the same flash. It is useless to rely on timing observations in order to decide which refer to the same battery. Practice has established the fact that batteries must be located one by one, and that all posts must be directed on the same offender until its position is well fixed. British, French and German Armies all have their different methods, but none is so good as our own "flash and buzzer board," which is installed at the headquarters. From it the O.C. can see at a glance which post is the first to pick up a flash. Moreover, as the C.O. (or the N.C.O. in charge of the flash and buzzer board) and all the observers are in constant touch and can hear each other on the same circuit, all know from the "leading observer" the precise time at which the flash in question occurred. Directed by the O.C. on a particular area, and warned by the "leading" observer of each recurrence of the flash, observers pick up the right one about the third or fourth round, and a trisection or quadrisection results. Locations are sent by telephone, and are subsequently illustrated by a little trace showing graphically how the rays cut and the amount of reliance which can be placed on each ray.

And now a word on the compiling of counter battery locations. A mass of evidence flows in almost without a pause. The air photographs, the telephonic reports from all location units, the written confirmation, the traces from the flash-spotting section, are all parts of the evidence. Since the beginning of 1917 this analytical work has been done, in the first instance, by the gunner whose duty it is to engage hostile guns; but the original compiling offices of the Field Survey Battalions (started in February 1916) were at work up to the last, and served as the location offices of the Army Headquarters.

In early days German emplacements were extraordinarily easy to identify on air photographs. The task of location units and of the compiling offices was to say which of them were occupied and by what calibre or type of gun or howitzer. The battle of the Somme taught the Germans to strive more and more for concealment, and to depend less on protection, and the task of identifying positions became correspondingly more difficult, but perhaps also more interesting.

As a general principle a small area in which the battery must lie was fixed by the reports from location units, and the final position was identified on, and plotted from, an air photograph. There remained, however, a number of cases in which the battery could not be seen on any air photograph. The positions of batteries in thick woods or in villages had often enough to be accepted on the unsupported evidence of sound ranging and flash spotting, and this also applied to very thick weather, during which no good photographs could be taken. On the other hand,

there were instances of the location of hostile batteries on the unsupported testimony of the air photograph.

Such are the outlines of our most interesting work at the Front. In conclusion I should like to add that the original and invaluable nucleus of regular officers and of trained surveyors from the Ordnance Survey gathered together over 4000 comrades of the new army, whose zeal and ability were one of the main factors in such success as we were able to obtain.

Before the paper the PRESIDENT said: To-night is eminently a soldier's night, and the particular phase of geography with which we are to deal is military surveying, which may contribute to geography in many ways. In this hall there have been many lectures on the results of military surveys in far-off lands, in Africa and in Asia, where much geographical work has been done with the object of showing the generals in command for the first time where it is that they have to conduct their campaign. Such work often covers large areas and results in the only maps we possess. It must be something like forty years since I gave a lecture in this hall on the geographical results of an Afghan campaign. To-night the subject is somewhat different. Military surveying on a campaign has become specialized, as will reveal itself in the course of the lecture.

Lieut.-Colonel Winterbotham then read the paper printed above, and a discussion followed.

The PRESIDENT: From the very interesting address which has been given us by Colonel Winterbotham you must have deduced this conclusion: that whatever may have been the deficiencies generally of many departments at the front—and there is no doubt that there were many—the particular department which included the business of surveying proved to be both efficient and useful. And for that efficiency and usefulness I have every reason to know that the Army is indebted very greatly to the energy and ability of the lecturer. A main object of this very highly specialized system of surveying was to locate the enemy's guns. It would be very interesting to know how far Colonel Winterbotham and his able assistants were successful in realizing the ideals which they set before them, and as we have here to-night Major-General Franks, the Inspector-General of Artillery, I will ask him to tell you precisely what he considers to have been the outcome of the system described by Colonel Winterbotham.

Major-General FRANKS: I should like to say that for a very long time in France I was working in very close co-operation with Colonel Winterbotham who has given such an extremely interesting lecture. I, of course, saw the picture from the gunner's point of view—but we are still very good friends! I think, speaking as a gunner, it is hard to say really what we owe to the Royal Engineers and the Ordnance Survey in this war. There are not many gunners here to-night, or you would hear a very big round of applause. When we started out to war our methods were very different from what they are at present. Now-a-days we have long got away from the time when gunners fought with their guns in the open. You get your gun down in a hollow and hide it away, and the enemy does the same. In 1914 our methods were distinctly primitive as compared with what they are now. The first job, as a rule, was to find the enemy gun, but the enemy very soon found that he had to hide

his guns. One used to get little maps from the most enterprising and gallant airmen. The airman would fly over the battery and drop a sheet of paper on which was a little sketch, occasionally showing a cross-road, a hedge, a church, and an enemy battery marked in one corner. You took that, plotted it on to your own map, made out where you thought the enemy battery was, calculated the angles and range, found a church spire for an aiming point, and started off. In the meantime the airman had gone back and was sitting over the enemy battery ready to tell you what happened, and correct your fire till you got it right on to the battery. Probably the first thing we found out was that the map was wrong, and that is what Colonel Winterbotham and the Royal Engineers have been putting right for us all through the war. When the map showed an enemy battery position 400 or 500 yards out, it was very difficult to hit it. Flash spotting, to which Colonel Winterbotham has referred, was one of the quite early developments. It was practically all done at night. I think flash spotting was first started down in the region of Bethune in 1915. We used to get up on the spoil heaps from the mines, with instruments for measuring angles and a rough telephone system, so that two operators a distance apart could try to get their instruments on to the same flash at the same time. And from those very rough beginnings in 1915 we got down to most perfect and marvellously accurate results before the end of the war. Those again were borne out by the sound-ranging, of which Colonel Winterbotham has also spoken, the results of which were absolutely astounding. You can all remember the great battle of Messines, which was rather a typical stereotyped battle of its kind. We were preparing some time for that battle, and one of the most important things we had to do was to locate every German gun and get it picketed or knocked out. There were hundreds of German guns in front of us, and between the air photographs, the Field Survey work, flash spotting at night, and sound ranging, we got on to the German guns and knocked them about so badly that they gave us very little trouble indeed during that battle. After the battle it was a very great pleasure to us to go and see our handiwork. We went over all those German battery positions and compared them with the records which had been worked out and mapped, for day by day during the battle fresh counter-battery maps were brought out, showing the positions as they shifted, and we found on comparing results with what we could see on the ground that we had got over 90 per cent. of the German guns absolutely accurately located. And what was most wonderful of all was that wherever there was a doubt about the position of a battery, in every case the sound-rangers were right : they had beaten everybody in accuracy. There is one thing Colonel Winterbotham did not mention in regard to the mapping work that was done for us, and that was the marvellous barrage maps. Everybody knows what a barrage is, and in those old stereotyped battles of Arras, Vimy, Messines, and the battles of Flanders in 1917, the infantry advanced by regular steps of about 100 yards at a time under a barrage. For a big battle these barrage lines had to be arranged so that there were no gaps in them, otherwise German machine-guns would have escaped. We had to have barrage maps covering a front of some 10 or 15 miles, showing lifts of 100 or 200 yards every four minutes, we will say, for a period of several hours at a time. When the plans of the battle had been made the Artillery plans had to be made, the lifts of this enormously long line of guns covering a front of about 15 miles all had to be accurately mapped, and these maps produced and issued down to Platoon Commanders, so that every officer went into battle with a regular map in front of him of exactly what he had to do from zero hour

when the attack started until six or seven hours later when his job was finished. All he had to do was to take the map with him and follow the timing of these lifts by minutes. He would know zero hour was 3 o'clock in the morning, and from 3 a.m. to perhaps night he would be able to tell as he came to each piece of trench what time the Artillery fire would lift and his men could charge into it; and they had to stick very close to the barrage. One of the wonders of the war was the way these barrage maps were produced before the battle. Last and very far from least was this point, that, owing to these excellent survey arrangements which have been described to you, the Artillery were able in the later battles to shoot straight off the map without any preliminary "registration" by actual shooting. The great counter offensive of the 4th Army last summer was an example of this, and of the enormous advantage of being able to conceal from the enemy beforehand the concentration of guns opposite him. In conclusion, I would like to say that we gunners owe the most tremendous debt of gratitude to the Royal Engineers, and the Survey Department in particular, for the help we have had all through this war.

Colonel HEDLEY: I should like to say, to start with, that we owe a great debt of gratitude to Colonel Winterbotham for his most interesting lecture. I am afraid he may have left you with the impression that the original Expeditionary Force went out ill-supplied with maps. As a matter of fact, they carried with them enough maps, I think, to lose some three or four hundred thousand in the course of the retreat from Mons, and those maps were very good maps for the kind of warfare which was carried on at that time. That is to say, for mobile warfare the original Expeditionary Force was very well equipped with maps, chiefly owing to the great foresight of Sir Charles Close, who was my predecessor at the War Office. Nobody had foreseen the situation which was going to arise. As soon as trench warfare began it became immediately obvious that the small-scale map, which was excellent for mobile warfare, was totally useless for trench warfare, in which it was necessary to locate a target within a few yards. The same circumstance cropped up all over the world. In the Dardanelles Expedition they had a map on the 1-inch scale. The Gallipoli Peninsula was not a place in which one could go and do a survey when one wished; but a map had been compiled chiefly from the French Survey in the time of the Crimea, and that map really gave a very good idea of the country. Nevertheless the need for a large-scale trench map became immediately obvious. An attempt was made to use this map for that purpose, and of course it was found to be perfectly useless. It was never intended for that purpose. In the same way in Mesopotamia the necessity for large-scale maps prepared from aeroplane photographs existed only so long as the opposing forces were sitting opposite to each other in trenches. As soon as that situation ceased the Army reverted to the small-scale maps, such as they were, and the need for the large-scale trench maps ceased. For Salonika maps had been provided by the War Office, but the original maps were totally useless for trench warfare, and Survey parties were organized, and gradually executed large-scale surveys, which were completed just before the Armistice was signed, but nevertheless in time to be extremely useful. It will interest you to know that on one occasion a captured Bulgarian map was found to be a copy of one of our maps which was constructed from an aeroplane photograph, so that they had preferred to use our map prepared from an aeroplane photograph rather than to make a survey of the ground which was in their own occupation. The need for all the large-scale maps which Colonel Winterbotham has described to you arose entirely from the needs of trench warfare.

Colonel Sir CHARLES CLOSE: The operations that have been described so ably by Colonel Winterbotham represent, I think, the largest Survey operation undertaken in history. It is not possible to compare anything that we have ever heard in this theatre with what we have heard to-night. How accustomed we are to sitting here on these uncomfortable benches and listening to Boundary Commission Reports! Now, let us take what a Boundary Commission is. It consists, perhaps, of half a dozen officers and non-commissioned officers, who work for a year or two and come back. They have very likely explored, or partly explored, a new part of the world, and they give us the results of the labours of, perhaps, half a dozen men for a year or two. We have been listening this evening to an account of the results achieved by the labours of thousands of men for over four years. As Colonel Winterbotham said, when the Armistice was signed there were over four thousand officers and men employed on this work. I have no hesitation in saying that, regarded from that standpoint, the operation was one of the greatest, or perhaps the greatest, in history; looked upon from the point of view of national importance, or world importance, it was by far the greatest—without comparison the greatest—Survey operation that has ever been undertaken. One very happy feature of the work that has been described was that it involved intimate co-operation between the Royal Artillery and the Royal Engineers, two corps that begin by being educated together, and afterwards very often separate a good deal, both in occupation and temperament. During this war they, like everybody else, have set themselves to do their best for the Army, and the net result was, I think, quite unrivalled. We had the best Survey organization of any of the armies on the Western Front. This result was due very largely, in fact mainly, to the happy accident that we had such officers as Colonel Hedley at the War Office, Colonel Jack in charge of all the Surveys in France, and Colonel Winterbotham who has given us the lecture, who ran all this great organization, and who were always ready to adopt new ideas. It is frequently thought that new ideas are rather at a discount in the Army. In fact, there is a story of an old general who is reported to have said, "But So-and-so suggested a new idea. A new idea is an innovation, and I cannot stand innovations." But that was certainly not the case with the Survey work at the Front.

This work on the Western Front reacted on all the other fronts; in particular it had the most happy effect on the operations in Italy. Colonel Winterbotham showed us only one slide illustrating work there, but perhaps I might quote Lord Cavan's dispatch, dated November 15, in which he said, "At 11.30 on the night of October 26 the bombardment of the hostile positions opened along the whole front. The fact that no single British gun had opened fire previous to this hour deserves special mention. Both heavy and field Artillery were registered by the 6th Field Survey Company R.E., and the fact that the bombardment and subsequent barrage were excellent in every way reflects the greatest credit on all ranks of this company." That shows how the good work on the Western Front reacted on the other theatres of war. Colonel Winterbotham referred to our work at Southampton. It was a very great pleasure to be able to assist in that far more important work going on in France. Our work was largely a sort of drudgery, but it had to be done, and we were glad to do it. It was lightened, however, in one or two little instances. We had the case of an officer who was to take out a great many thousand maps, weighing some tons. He was met by another officer, who said, "If you have the maps, I will put them in my pocket and get away

with them." I also had the case of a woman worker who was engaged in folding the maps, and she wrote to me as follows: "Sir,—I much regret that I am obliged to ask your permission to leave the Ordnance Survey, but I was unexpectedly married this morning."

Colonel JACK, R.E.: General Franks spoke of the efficiency of the Field Survey Battalions. I would like to mention very shortly some of the reasons for that efficiency. First of all there were the officers of the Field Survey Battalions and, in particular, the commanding officers. Colonel Winterbotham was the first in the field of these commanding officers, and we owe an enormous amount to him. The development of the Survey organization in France is mainly due to his energy, initiative, and fertility of ideas. Very few people are in a position to realize the tremendous burden that fell on the shoulders of the commanding officers of those Field Survey Battalions. Colonel Winterbotham has spoken very lightly of the problems with which they had to deal, but I can assure you from what I saw—and I had a great deal to do with them—that they had a most anxious and trying time all through, and especially just before and during operations. They had a very complicated organization to look after, and a lot of machinery for which they were responsible. They had to print maps at very short notice, and finally they were responsible for delivering large quantities of those maps to troops that were very often hard to find, with transport that was always inadequate and generally broken down. I am afraid that the word "transport" will be found graven on the hearts of all commanding officers of the Field Survey Battalions. Besides the commanding officers there were, of course, the other officers of the Field Survey Battalions, and I would like to say what a very fine lot of officers they were. They were nearly all holding temporary commissions, and you could not possibly find a finer body of officers anywhere. The non-commissioned officers and men were also mainly duration-of-the-war men, and they distinguished themselves throughout by their zeal and their whole-hearted devotion to duty. Finally I would like to mention a small though very important proportion of the Field Survey Battalion personnel, that is to say, the non-commissioned officers and men who came from the Ordnance Survey. The Ordnance Survey trains these surveyors and topographers, and they form a very high class in the topographical world. Many of them are very fine draughtsmen, and a good number of them are, in addition, that extraordinarily valuable class of man, the draughtsman who is able to use his judgment in compiling difficult material and make a good map from it. The debt we owe to that small number of men and, incidentally, to the Ordnance Survey who trained them, is, I think, incalculable. They undoubtedly formed the backbone of the mapping branch of the Field Survey Battalions.

Colonel BEAZELEY: The lecture Colonel Winterbotham has just given is specially interesting to me, as I was responsible for the Field Survey work in Mesopotamia on the Kut Front from the time we started to take Kut to the time we occupied Baghdad. The description of the instruments and personnel that Colonel Winterbotham has had at his disposal fairly makes my mouth water. The only personnel I had for field work was two Indian surveyors, and it is entirely due to the devotion to their duty that these two Indian surveyors showed that my work was as successful as it was. I will not deal with mapping, as that was most ably carried out by Colonel Gunter who supplied the Force with all the maps required, and I hope one day we may have the pleasure of hearing him lecture here. My work was mainly connected with Field Survey, and my most important duty was resecting batteries,

providing them with Artillery boards, spotting enemy guns and targets, and giving the batteries true bearings and correct ranges. I should like to say a word in regard to the efficient way in which the gunners helped me; nobody could have aided me more effectually than they did, as far as lay in their power. And I think I owe my good health during operations to the splendid way in which they fed me as well. My work was, to a large extent, done from the trench ladders which were put up unpleasantly close to the enemy's lines. More than once I had the somewhat unpleasant experience of being honoured with shrapnel. My system was to get up one trench ladder, mark the flash of an enemy gun, travel as fast as I could over the rough ground in my Ford van to a second ladder, observe, and by means of a theodolite at the base of the ladder I was able to fix the position of the enemy gun and mark it on the Artillery board. Later on, when we crossed the Tigris at Shumran, the troops marched at such a pace after the retreating enemy that I was unable to carry on any more triangulation, and the work had to be done by means of a bicycle wheel fitted with a cyclometer, which occasioned somewhat amusing remarks from the ranks. I am not going to worry you with precise details of my system—it was all rough-and-ready; but I am glad to say I was able sometimes to give the position of some 5·9 howitzers which were troubling our troops, and the batteries were able to knock them out. Later on my Survey Section was much strengthened, and I was able to do independent work. I took up air survey for supplementing the work, when air photographs could not be taken. It involved going over the enemy lines and producing a map, sometimes 1 inch to the mile, sometimes ½ inch to the mile, so that the whole ground could be mapped and printed before the troops actually went over it. I am sorry to say my experiments came to an untimely end, as the aeroplane I was working in was shot down by the enemy, and I was taken prisoner. Conditions in Mesopotamia are, of course, very different from those in France, because over practically the whole area there are no maps at all, and the only way in which we could get maps of enemy territory made was to compile the maps from air photos. Where these failed owing to lack of fixed points to tie them down, or to gaps left in the set, or to lack of time to photograph the area, recourse had to be made to actual survey from an aeroplane, a system I was experimenting in and making use of when shot down.

The PRESIDENT: I think you will agree with me that the gallant officers of the Royal Artillery and of the Royal Engineers have bestowed enough mutual admiration on each other to-night to last them for a very long time. I can only ask you now to give a very hearty vote of thanks to Colonel Winterbotham for his very interesting and most instructive address to us, and to all the gallant gentlemen who have so well supported the discussion.

THE PRISMATIC ASTROLABE

John Ball, O.B.E., D.Sc., M.Inst.C.E., of the Survey of Egypt, and H. Knox-Shaw, M.A., Director of Helwan Observatory

Read at the Meeting of the Society, 14 *April* 1919.

THE conclusion reached by Colonel Woodroffe, in the excellent paper on "The Astrolabe and Wireless" which he recently read before this Society as the result of his experience on the Peru–Brazil boundary (*G.J.*, 47 (1916), p. 345), that the prismatic astrolabe is to be preferred to the theodolite as a field-instrument for determining positions on boundary and other surveys by reason of its greater convenience and the higher precision of its results, as well as the great interest aroused by his paper among the Fellows of the Society which was evidenced in the discussion following the reading, has led us to make a careful trial of the instrument, and to carry out a series of comparative observations with the view of determining the relative precision of the results obtainable with it and with a modern theodolite.

The outcome of our trials is to confirm the conclusion of Colonel Woodroffe, except in certain special cases to which we shall make reference further on. Indeed, so convincing in regard to general survey practice did the results appear to us, that we have continued our work with the astrolabe so far as to produce an English handbook describing its construction, adjustments, and use in the field, and to compile tables and diagrams for facilitating its employment by British surveyors.

The present paper is largely compiled from this 'Handbook of the Prismatic Astrolabe' which has just been published by the Egyptian Government.*

Choice of Type of Astrolabe.

The prismatic astrolabe, invented by MM. Claude and Driencourt, is made by M. Jobin, of 31, Rue Humboldt, Paris, in three sizes. The smallest size (the "Petit modèle"), costing about £50 (pre-war price), enables latitudes to be observed to about 1″, and time to about 0·08 second, and is the type best adapted for exploratory geographical surveys, being extremely compact and portable. The precision of the time observable varies as the cosine of the latitude, being thus greatest at the equator and zero at the poles; the figure given is for latitude 45°. In our investigations we have employed this type. Both with the astrolabe

* 'A Handbook of the Prismatic Astrolabe, being a concise and practical guide to the use of the instrument in the field, designed for the use of geographical and hydrographical surveyors, with star-tables adapted for the easy preparation of programmes of observation in any latitude from 55° N. to 55° S., by J. B. and H. K. S. Published by the Egyptian Government at the National Press, Cairo, 1919.

and with the modern theodolite the size and weight of the instrument increase very rapidly in proportion to the increase of accuracy in the observations, and the precision obtainable with even the smallest sized instruments is very remarkable. Since a precision of about one-tenth of a second of time is all that is possible in time-recording on ordinary surveys, it would appear that for such surveys the main advantage of the geodetic form of astrolabe over the smallest size lies in the greater magnification of its telescope permitting of the observation of a larger number of stars, rather than in the greater precision of observation possible with it.

Comparison of Astrolabe and Theodolite.

Experience during the last two decades has shown us that when latitude and time are both to be determined with a theodolite, the most accurate method is that of equal altitudes of three or more stars, thus making use of the same essential principle which is utilized in the astrolabe. It was hence obviously advisable, in any comparison of the two instruments, that the observations with the theodolite should be made by the method of equal altitudes rather than by any of the more commonly used field methods which depend on circle-readings.

The theodolite selected for the tests was a five-inch Troughton & Simms instrument of recent construction, having a telescope with a power of about 30 (the same as that of the astrolabe), and provided with a level sensitive to 5″ per division on the microscope-arm.

The constant altitude chosen for the observations with the theodolite was about 30°, as this is the most generally convenient altitude with that instrument. Though a little more accuracy might have been gained by the uniformity of refraction at the higher altitude, there would at the same time have been a loss of precision owing to the use of the diagonal eyepiece.

The problem to be solved by the tests was thus reduced to that of ascertaining the average deviation of a single altitude from the mean of a large number of star-passages observed (1) with the small-sized astrolabe and (2) with the five-inch theodolite, each instrument being used under ordinary field conditions.

The observations were carried out at Helwan Observatory on four nights in July 1917. The programmes were prepared so as to observe on each night an equal number of stars of about the same brightness at about equal intervals of time with each of the two instruments, and each of us observed half the total number of stars with each instrument. In the case of the theodolite the bubble-readings were estimated to the tenth of a division as soon as possible after the observation, and the dislevelment allowed for in the ordinary way. The times in all cases were taken on the same chronometer, using the Dent "time-of-flight" watch. In all, fifty observations were made with the small-sized astrolabe, and fifty-three with the theodolite. On computation of the results it was found that the

probable deviation of a single observation from a constant altitude was 3″·2 with the astrolabe, and 5″·4 with the theodolite.

These deviations are considerably larger than we expected with either instrument. In the case of the astrolabe, our observations were made before either of us had had much practice with the instrument; and in the case of the theodolite, the accuracy was doubtless influenced to some extent by the fact that a ruled glass diaphragm was used in the eyepiece instead of the usual spider-lines. With more experience with the astrolabe and a fine spider-line diaphragm in the theodolite, it is likely that the deviations would be considerably smaller. But the results represent very fairly, we think, the relative precision of observations with the two instruments under good field conditions, and show conclusively the superiority of the astrolabe. The greater precision of the results in the case of the astrolabe is doubtless due in the main to two factors. Firstly, the doubly rapid relative motion of the star-images in the astrolabe as compared with the motion of the single image relative to the fixed wire in the theodolite; and secondly, the non-dependence of the astrolabe on level-readings.

There can thus be no question that where the essential object of a surveyor is to determine latitude and time with the greatest possible precision he should prefer the astrolabe to the theodolite. The case may be otherwise on some geographical and hydrographic surveys, where only *good* fixation of positions, and not the highest obtainable precision, is required, while economy of time and transport are of great importance. The theodolite may then be much to be preferred to the astrolabe, because of the far greater variety of uses to which it can be put. While the astrolabe cannot be used for any other purpose than to determine latitude and time, the theodolite can be employed in terrestrial as well as celestial observations, and if economy of transport is a great consideration and only one instrument can be taken, the theodolite should always be chosen rather than the astrolabe.

When only one night can be spent at each camp, as for instance usually happens on military reconnaissances, it would be folly to rely on the astrolabe, unless it is certain that cloudless skies and moderately still air may be depended on, which is seldom the case. We have deliberately rejected the astrolabe from use on recent military reconnaissances for the above reason, employing a 5-inch theodolite instead. Whenever it has been practicable to employ the method of equal altitudes with the theodolite, the results have not been so very far behind those which could have been obtained by the astrolabe in precision. The theodolite has another advantage over the astrolabe: its stability in a moderate wind. Our experience with the astrolabe is that in anything approaching what sailors call a "fresh breeze" observations are quite impossible, even when the wind-screen is employed, unless the instrument is exceptionally well sheltered.

Remarks on the Practical Use of the Prismatic Astrolabe in the Field.

Our experience with the astrolabe, both in the above-mentioned trials at Helwan and in the field, led us to the view that for the instrument to be utilized by surveyors to the extent which its capabilities deserve, three things were highly desirable. The first desideratum was a clear and concise guide to the adjustment and use of the astrolabe in the field, adapted to the easy comprehension of the ordinary surveyor. The elaborate French treatise by the inventors is an excellent work, but is rather a book for the trained mathematician than for the average surveyor. Secondly, some means should be found for shortening the preliminary work of preparing star-programmes for observation. Colonel Woodroffe records, in his paper already cited, that it occupied no less than five months of his spare time to prepare preliminary star-programmes for a survey extending over three degrees of latitude. Thirdly, it was desirable if possible to shorten the process of the final reductions, so as to enable the results of the observations to be arrived at within a shorter time after completing the observations themselves than is practicable by the method of reduction recommended in the French manual.

These three desiderata we have set ourselves to supply as far as possible in our handbook, which, though dealing only with the application of the smallest size of astrolabe in general geographical surveying, will yet, we trust, be found a good introduction to the use of the instrument for surveyors who desire to employ the larger type of astrolabe on geodetic or boundary surveys of higher precision.

As regards the description of the astrolabe and its adjustments, we were faced at the outset with the necessity of supplying English names for the various parts of the instrument, and in this we endeavoured to choose terms which combined brevity with adequate description. An outline drawing of the small-sized astrolabe, with the names we have adopted for its different parts, is shown in Fig. 1. The notes given in our handbook on the adjustments of the instrument and on the practice of observation with it will be found, we believe, to cover all the difficulties likely to be encountered by a beginner, since they have been compiled during our own early essays in its use.

Concerning the second point, that of shortening the preliminary work of preparing star-programmes for observation, Colonel Woodroffe had already recorded his belief that if star-tables "were prepared every few years for all latitudes between 60° N. and 60° S. by some patriotic body, the use of this instrument (the prismatic astrolabe) would become almost universal" (*G.J.*, 47, p. 354). We have not done quite all that Colonel Woodroffe hoped for, though we have gone some considerable way towards it in the star-tables appended to our handbook, wherein we have tabulated sidereal times and azimuths of about 17,000 star-passages. We have confined our tables to Nautical Almanac stars of the fourth

magnitude and brighter, to latitudes ranging from 55° N. to 55° S., and to those stars whose azimuths are within the middle 40° of each of the four quadrants. This necessary limitation of the tables will not, we are assured, prevent their being adequate to all the ordinary needs of the geographical surveyor, while to one engaged in the more refined operations of geodesy they will go a considerable way in shortening his labours. As

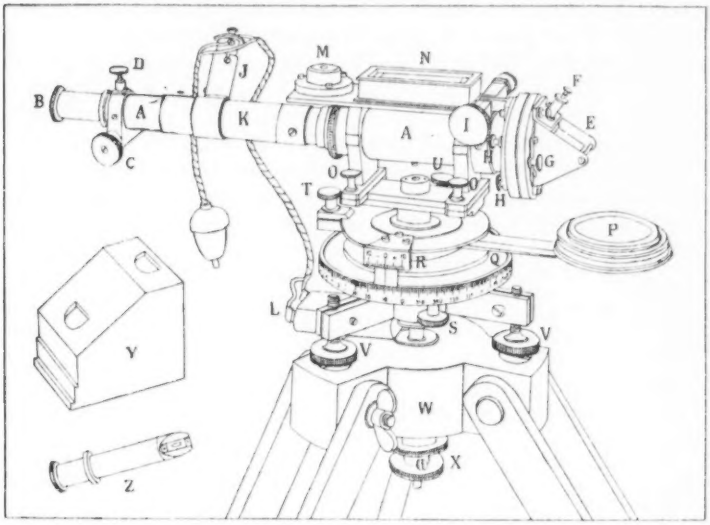


Fig. 1.

AA, Telescope.
B, Eyepiece.
C, Focussing screw.
D, Screw clamping telescope in focus.
E, Prism in front of object-glass.
F, Spiral spring holding prism in position.
G, Collimation-screw for vertical wires.
HH, Collimation-screws for horizontal wires.
I, Clip-screw.
J, Lamp-holder.
K, Sleeve of lamp-holder.
L, Dry battery.
M, Spirit-level.
N, Trough compass.
OO, Screws clamping telescope to lower part of instrument.
P, Artificial horizon.
Q, Lower plate, carrying horizontal circle.
R, Sector, below which is the fiducial mark of the horizontal circle.
S, Lower plate clamp.
T, Sector clamp.
U, Azimuth clamp.
VV, Levelling screws.
W, Tripod.
X, Spring and screw fixing instrument to tripod.
Y, Wind-screen.
Z, Auto-collimator.

regards the limits of latitude, 55° N. carries us to Labrador and 55° S. to Cape Horn, so that the vast majority of future survey operations will be found well within the latitudes covered by our tables.

In confining our list to stars of the fourth magnitude and brighter, we were guided by the circumstance that although fainter stars can be easily observed with the larger forms of astrolabe, they cannot be sufficiently

well seen for accurate observation with the small size of instrument, even on moonless nights.

The restriction of our star-tables to azimuths within the middle 40° of each of the four quadrants will at first sight appear to be remarkable, as it cuts out both circum-meridian stars and stars near the prime vertical, which are the very stars recommended for observation by Colonel Woodroffe; but it will be found in practice to impose comparatively little restraint on the number of useful observations, while the saving of labour in omitting other stars from the tables and from programmes is considerable. To make clear the reasons which have guided us in deciding to include only stars within the azimuth-limits named, it is necessary to consider the graphic construction which invariably forms the last step in the reduction of astrolabe-observations. The final position resulting from the observations is found as the centre of a circle which is as nearly as possible tangential to a number of position-lines analogous to Sumner

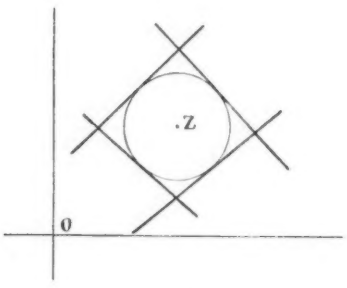


Fig. 2.
Stars near the middle of the quadrants.

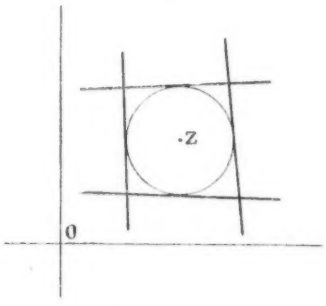


Fig. 3.
Circum-meridian and prime vertical stars.

lines on a chart. Let us take a case where there are four of these position-lines, corresponding to four star-observations with the astrolabe. If the stars are observed near the middle of each quadrant, the construction will be as depicted in Fig. 2; while if circum-meridian and prime vertical stars are chosen, the diagram will take the form shown in Fig. 3. The position, Z, is equally well defined in each case; but the first-named arrangement, which we advocate, has the very great advantage that at any given place the number of stars available for observation is vastly greater than in the other, which is the one recommended by Colonel Woodroffe. It will be found that the number of stars crossing the 60° altitude-circle within a range of 20° on either side of the meridian is small compared with the number crossing within a similar range about the middle points of the quadrants. Stars near the middle of the quadrants serve to locate the point with about equal precision in both latitude and longitude, which is usually the result aimed at by the observer.

The total number of Nautical Almanac stars of magnitude 4·0 and brighter which cross the 60° altitude-circle in the 24 hours within the ranges of azimuth mentioned, in latitudes 30° N., 0°, and 30° S., for instance, are :

Latitude.	North of the prime vertical.		South of the prime vertical.	
	Azimuths within 20° of meridian.	Azimuths within 20° of middle of a single quadrant.	Azimuths within 20° of meridian.	Azimuths within 20° of middle of a single quadrant.
30° N.	10	27	0	34
0°	8	35	12	41
30° S.	16	27	12	39

The manner of using our tables for the preparation of programmes in the field is extremely simple. An observer in about lat. 29° 15′, for instance, desiring to observe with the astrolabe between 8h. and 10h. of sidereal time, would merely take from the star lists for latitudes 29° and 30° the names, magnitudes, sidereal times, and azimuths of all stars making their passage between 8h. and 10h., and then by simple interpolation find the times and azimuths for lat. 29° 15′. The tables are based on the star-places given in the Nautical Almanac for 1918. In time, of course, they will go out of date owing to changes due to precession. But the changes will not sensibly affect the utility of the tables for the next fifteen years.

Observations and Reduction.

Four properly chosen stars are all that are usually necessary for a good geographical fixation; even where the precision sought is the highest possible with the small-sized astrolabe, it will seldom be necessary to observe more than eight stars. Instead of calculating the altitudes with an assumed time and entering on the graphic construction with differences of altitude, we calculate the times with an assumed altitude and base the graphic construction on differences of time. This process of reduction has three advantages over MM. Claude and Driencourt's method. Firstly, it requires no preliminary knowledge of the chronometer-error; secondly, it shortens the calculations by not requiring either natural numbers or tables of Gaussian logarithms, being in fact the ordinary calculation for finding the time from a single altitude with which every geographical surveyor is already familiar; and thirdly, it enables the whole of the numerical calculations to be done, if desired, before the observations are taken, leaving only the graphic construction, which is but a matter of a few minutes, to be performed in order to have the final result. This last advantage may be of great importance in geographical surveys, where it is desirable to have the results at the earliest possible moment after completing the observations, in order to arrange for the next day's march.

In addition to the general case where four stars have been observed,

we have considered the special cases likely to arise in exploratory surveys, where three, or even two, observations only can be taken, by reason of clouds or other hindrances; and we have discussed the conditions necessary for obtaining the best results in these cases.

Ball's Astrolabe Diagram.

The geographical surveyor making use of the small-sized astrolabe will as a rule require no further aid in the preparation of his programme than is given in the star-tables in our handbook, as the tables include all the stars he is likely to observe. But when the geodetic type of astrolabe is to be employed on boundary surveys, it will generally be advisable to make more extensive programmes, utilizing stars fainter than the fourth magnitude. To facilitate this, one of us has issued as a separate publication * a diagram which will enable the hour-angle and azimuth, at which any known star will cross the altitude-circle of 60°, in any degree of latitude from 55° N. to 55° S., to be read off at a glance; the hour-angle can as a rule be read to the nearest minute of time, and the azimuth to the nearest half-degree.

The diagram was originally designed for the purpose of preparing the star-tables in our handbook, in which work it has saved us an enormous amount of time. We originally employed the ingenious "abaque" of the French Hydrographic Service for this purpose, but we frequently found it impossible to read off the results with sufficient precision, especially in high latitudes; and the use of the movable sheet of tracing-paper which forms an essential part of the "abaque" was found to be beset with difficulties owing to its expansion and contraction being different from that of the ordinary paper below it, besides being very trying to the eyes.

The diagram consists of a series of curves, each corresponding to a particular degree of latitude, drawn on a rectangular graticule with polar distances and azimuths as co-ordinates, and with hour-angles marked off along the curved latitude lines. It does not require the use of any extra implement such as a straight-edge of sheet or tracing-paper; and being complete in itself and independent of star-positions, its accuracy will not be affected by any shrinkage of the paper on which it is printed, nor by the lapse of time.

Experiment with the Celestial Globe as an aid in preparing programmes for Astrolabe Observations.

Theoretically, a celestial globe fitted with a graduated horizontal circle at an altitude of 60° above the horizon forms an excellent means of

* "Ball's Astrolabe Diagram, designed for facilitating the preparation of programmes of stars to be observed with the prismatic astrolabe, in all latitudes from 55° N. to 55° S." Published by the Egyptian Government at the National Press, Cairo, 1919.

preparing star-programmes for astrolabe observations; for if the axis is elevated to the latitude of the place and the globe is turned to bring any star to the altitude of 60°, the azimuth of the star can be at once read off on the graduated circle, and the sidereal time is equally readily found by noting the right ascension of the meridian as marked round the equator. We made the experiment of fitting a circle of this kind to a celestial globe, and we found the contrivance an admirable one for demonstrating the use of the astrolabe; but to be of real service for the preparation of programmes, a globe would have to be much more accurately made than any of those at present sold by instrument makers.

Use of the Astrolabe-method with the Sextant.

A sextant may be made into a substitute for the astrolabe by clamping it at 120° and using it in conjunction with an artificial horizon. With a sextant used in this manner, the same star-tables and method of reduction may be employed as with the astrolabe, and the apparent movement of the images as seen in the telescope will be the same. Any equal-altitude method, whether the constant altitude be 60° or some other value, eliminates all the instrumental errors of the sextant as well as errors in the assumed refraction, and is preferable on that account to the ordinary methods of single altitudes; but it is only at the altitude of 60° that the star-tables employed for the astrolabe can be utilized with the sextant. The method may be found of service in shore-observations in the course of hydrographic surveys where the surveyor has neither an astrolabe nor a theodolite of suitable type available for his observations.

Relations of the Astrolabe-method to other Processes of fixing Geographical Position. Sumner lines, position lines and their application in Land Surveys.

Not the least interesting of the results of our studies of the astrolabe have been the side lights they have thrown on some other methods of position-finding, with which the astrolabe itself has at first sight no apparent connection.

In our consideration of the graphic construction by which the final results are invariably obtained from astrolabe observations, we were struck by the fact that the lines to which the circle is made tangential (called "perpendiculars" by Colonel Woodroffe) are exactly the same thing as the "position lines" employed in the 'New Navigation,' a modern development of "Sumner lines" now frequently used in fixing a ship's place at sea. It was a little astonishing to us at first to find these position lines, which have hitherto only been utilized by sailors in the comparatively rough process of fixing a ship's place within a mile or so at sea, employed in the reduction of geodetic observations. But a very small amount of investigation showed us that any roughness in the results obtainable in the 'New Navigation' arose entirely from the roughness of the observations practicable under sea conditions, and not at all from the graphic

construction employed to reduce them. Once this point was recognized, it soon became apparent that the position-line principle was capable of wide application in geographical surveying.

There are various constructions for plotting the position lines from the observed altitudes and Greenwich times. The earliest is that devised by Captain Sumner in 1843, now obsolete. Sumner's process involved the working out of two separate calculations for each observed altitude, and it was soon found that the position lines could be plotted in another way with less calculation. The distance of the position line from an assumed position must be equal to the difference between the altitude computed for that position and the observed altitude; and since the circumference of a circle is everywhere perpendicular to the radius, the position line must be perpendicular to the bearing of the celestial body

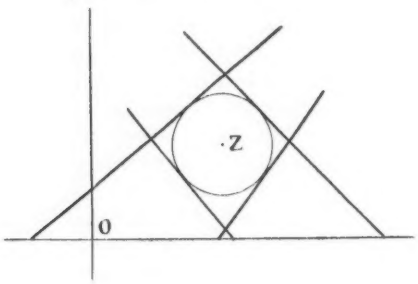


Fig. 4.
Perfect observations.

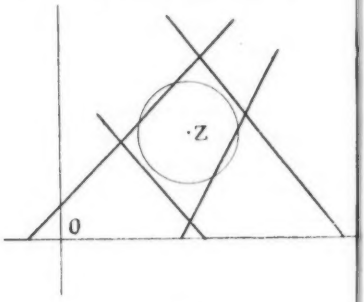


Fig. 5.
Imperfect observations.

whose altitude is observed. This forms the basis of the process known as the 'New Navigation' for fixing a ship's position at sea.

The construction employed by MM. Claude and Driencourt in their method of reducing astrolabe observations is exactly the same as that commonly used in the 'New Navigation,' except that since the number of position lines, each corresponding to a single star-observation, is greater than two, the various position lines will not intersect in a single point owing to small observational errors and to error in the assumed constant altitude of observation. It can easily be proved that if the observations are all perfectly made, the position lines will all be tangential to a circle having for its radius the error of the assumed constant altitude, and that the centre Z of this circle (Fig. 4) is the true position. In practice, the observations will not be perfect, and the most probable position (Fig. 5) is the centre of that circle which is most nearly tangential to all the position lines.

Yet a third construction for drawing the position lines, and the one we have ourselves adopted for astrolabe observations, is based on the fact

that since for any particular star any difference between its observed and calculated altitude corresponds to a certain difference between the observed and calculated times of its observation, we may plot the position line from a knowledge of the star's bearing and the computed and recorded times of its observation, neglecting the question of altitude altogether. And in observing with the astrolabe it is *time* which is recorded, and nothing else; so that the method is very direct in theory, besides having the practical advantages referred to on p. 35.

The above short digression on the subject of position lines will make it easy to follow certain conclusions at which we have arrived in regard to the wider application of the position-line principle. In the first place, it is obvious that the graphic process of reduction employed with the astrolabe is not peculiar to the altitude of 60°, but may be very conveniently employed in the reduction of *any* observations by the method of equal latitudes of three or more stars. We have for years made use of equal-altitude methods in the simultaneous determination of time and latitude on land with the theodolite, and have used the rather cumbrous simultaneous-equation process of reduction, with or without least squares, all unaware that a simple graphic process would have given us equally precise results with less labour and in less time.

A very little further consideration shows us that the process is not even restricted to *equal* altitudes, but is applicable, with the same saving of time and labour, and with a similar degree of rigour, to the case of four or more stars, all observed at *different* altitudes, the altitudes in this case being of course actually read on the circle of the theodolite or on the arc of the sextant employed. But this is equivalent to employing the 'New Navigation' for fixing positions on land, the only differences from nautical practice being the greater number of objects sighted, the higher precision with which the altitudes can be measured on land, and the employment of the circle tangential to the resulting position lines in the final location of the position. We are thus led to the conclusion that the 'New Navigation,' far from being merely a rather rough method of finding a ship's position at sea, is really one capable of very considerable precision for fixing geographical positions on land. The 'New Navigation' will in fact be found a particularly convenient and accurate method in cases where only a limited time is available for fixing both the latitude and longitude of a station and where the Greenwich time is known—as for instance in fixing positions on shore during a hydrographic survey, or in determining positions in the course of exploratory geographical surveys on which chronometers or apparatus for receiving wireless time-signals are carried. We have only to measure the altitudes, at known instants of Greenwich time, of four stars, one near the middle of each quadrant, in order to have the data for a good fixation both in latitude and longitude; the altitudes need not be even approximately equal, it will not be necessary to prepare any programme, and it will very

seldom happen that suitable stars are not available at any time of the night when the sky is clear. If the reduction is made by calculating the altitudes and bearings for an assumed approximate position, and then plotting the position lines from the differences between the calculated and observed times, in the same manner as for astrolabe-observations, finally locating the true position as the centre of the circle which is most nearly tangential to all the position lines, it will not be necessary to "change face" with the theodolite, nor to know the index-error of the sextant; for all *constant* errors in the altitude-measurements are completely eliminated in the graphic construction.*

A third conclusion to be derived from our study of the astrolabe is that the use of the circle tangential to the position lines may occasionally be of service in the 'New Navigation' when practised at sea. In ordinary navigation only two sights are usually taken, and of course two sights admit of only one solution. But the 'New Navigation' is sometimes used on surveying ships for locating soundings or dangers at sea, and the practice is then to take more than two sights in order to find the position more accurately. When three sights have been taken, the three position lines commonly do not pass through a single point, but form a "triangle of error." It has been usual up to the present time to place the final position at a point somewhere within the triangle according to the observer's judgment, and if the errors in the measured altitudes are known to be of an irregular nature, that is the only thing to be done. But with careful observations the errors in taking the altitudes will generally tend to be of a constant nature, all the stars being observed too high or too low by about the same amount, principally owing to the uncertainty of the proper allowance for dip. When this is the case, a consideration of the construction used with the astrolabe shows us that the point should properly be chosen as the centre of a circle touching all the three lines forming the triangle of error.† *Four* circles, one inscribed and the other three escribed, can be drawn to fulfil this condition. To discriminate which of the four circles is the correct one, we have only to remember that since by hypothesis the errors of the measured altitudes are of the same sign as well as equal in magnitude, the azimuths of the three stars must either all point towards the centre of the circle or else all be directed away from it; it will be found that only one of the four circles will satisfy this condition, and the centre of that particular circle is the point required, which may or may not be situated within the

* Some further practical remarks on this method, with a fully worked-out example, are given in a small pamphlet, 'Notes on the Working of the New Navigation,' by John Ball. Published by the Survey of Egypt, Cairo, 1918.

† That a similar solution is not possible for the triangle of error in plane-table resection is because in this latter case the objects sighted are terrestrial ones situated at different finite distances instead of being all practically at an infinite distance as are the celestial bodies.

triangle of error. This deduction from a study of the astrolabe may serve to avoid many doubts as to the proper location of a point by three star-altitudes in marine surveying. When *four* altitudes are observed, of course the solution is still simpler, the position being given by the centre of the circle which is most nearly tangential to all the four position lines.

Before the paper the CHAIRMAN (Sir AUBREY STRAHAN) said: The paper for this afternoon relates to the Prismatic Astrolabe. Both Dr. Ball and Mr. Knox-Shaw are in Egypt, but Mr. Hinks will give us a summary of their paper.

Mr. Hinks then read extracts from the paper printed above, and a discussion followed.

The CHAIRMAN: The subject brought before us this afternoon has been somewhat technical. It seems a question whether the astrolabe can displace in any way the theodolite, or under what circumstances it can do so. Colonel Lyons, will you be so kind as to open the discussion on this matter?

Colonel LYONS: This is an extremely interesting paper, but it is a rather difficult one to discuss satisfactorily. While I have read about the prismatic astrolabe, I have never had an opportunity of handling one of these instruments, and that makes a very great difference in speaking of its value in surveying. So far as I can judge, I should say that Dr. Ball's and Mr. Knox-Shaw's opinions as to its limitations are very just. It will certainly not do to limit oneself altogether to the use of the astrolabe and reject the theodolite. But if I may say so, the paper interested me more from the point of view that we have here, not perhaps a new but another instrument for field surveying, with its limitations and advantages very carefully worked out and stated. I have known Dr. Ball now for nearly twenty-five years as an extremely capable surveyor; more than that, he is one who has always taken an especial interest not only in thoroughly understanding his instruments, but in making the very best use of them, and of course instruments in the hands of a surveyor of that character are put to their fullest use. I often think that it would be well in surveying if we were all to bear in mind that particular point of our work: that it is impossible to know one's instrument too well if one is going to get the best results out of it. Mr. Knox-Shaw, who is an astronomical observer of very high efficiency, and who is the Director of the Helwan Observatory near Cairo, makes, with Dr. Ball, a very strong combination, because he naturally comes to the question from rather a different side. As they together have come to the conclusion that the instrument is a valuable one, and also that they would prefer to make certain alterations in the procedure, I am sure every one who has to do with work of this class will give very great weight to their conclusions; and as soon as these instruments are again more readily obtainable will wish to satisfy themselves on the same line. I am afraid this does not amount to very much of a discussion of the paper, but I do not really feel capable of saying more without having had an opportunity of using one of these instruments. I should, in conclusion, like to thank Mr. Hinks very much indeed for the excellently clear way in which he has put before us the summary of a paper that in itself, so far as I have had time to read it, is a difficult one.

Mr. J. JACKSON (Chief Assistant, Royal Observatory, Greenwich): It will be advisable for me to state first of all what experience I have had of various instruments. As an astronomer I have been accustomed to observe with large instruments, and in particular with the transit circle of the Royal Observatory,

Greenwich. About three years ago an astrolabe purchased by the Admiralty was sent to us for trial. At the time I was quite pleased with the performance of the instrument, but during the past year I have had considerable experience with a 5-inch micrometer theodolite, and have formed a very high opinion of it indeed. With regard to the optical principle of the astrolabe there is one point which appears to me to be objectionable. The two images are formed by light which passes through different halves of the objective. Half of an objective acts essentially like a small-angle prism. Each image is thus in reality a short spectrum. The eye indeed does not see much colour about the images, but they appear decidedly elongated in the direction joining the two images. As the spectra lie in opposite directions, the time of the coincidence will depend on the colour sensitiveness of the observer's eye and on the colour of the star. Moreover, the elongated images are distinctly annoying to the observer. I am quite sure this point will prevent the astrolabe ever becoming an astronomical instrument of the highest precision.

There is no doubt that the astrolabe has several good features. There are no circles or bubbles to read. The adjustments are very easily made. The time of coincidence of the two bright images can be observed in a perfectly dark field. If the temperature and pressure can be assumed constant throughout the observations the refraction can be eliminated. [If the angle of the prism is known and made use of, the thermometer and barometer must be read.] A great claim is made for the instrument in that it is unnecessary to read any circles. I am not quite sure that this tends to increased accuracy. A large amount of the success in the use of an astrolabe depends on ability to estimate time accurately. Two-tenths of a second of time correspond to three seconds of arc, and it is quite easy for even skilled observers to make errors of this amount.

The great drawback to the use of the astrolabe is its very limited use. It can only be economically employed when both time and latitude are to be determined. As it has no accurate horizontal circle, it cannot be employed for the determination of astronomical azimuths, and the determination of azimuth is perhaps the commonest application of astronomy to survey. Dr. Ball and Mr. Knox-Shaw suggest observing near the middle of the four quadrants. The real reason for this is that the instrument is not suitable for observing near the meridian. Stars near the meridian move very slowly in altitude, and the astrolabe is not convenient for observing objects moving slowly in altitude. Also there are very few stars indeed which are to be found at an altitude of 60° near the meridian. In fact, a great drawback to the instrument is the long spells one has to wait to get stars. With a theodolite we can alter the altitude at which we observe, but with the astrolabe no alteration of the observed altitude can be effected. For the determination of latitude apart from time the instrument is wholly unsuited.

The authors of the paper suggest two reasons why they get more accurate results with the astrolabe than with the theodolite. The first is the doubled speed of approach of the two images. I doubt, however, whether one can observe the passage of two moving images as accurately as one can observe a moving image cross a fixed wire. When I myself observed with the astrolabe I sometimes varied the method of observing by taking the times at which the two images passed two horizontal wires. The second reason given for the accuracy of the astrolabe is that there is no bubble to read. But in fairly steady conditions the bubble should not give much trouble, and the authors state that in windy weather the theodolite is the better instrument.

Captain McCaw: One has to look on the prismatic astrolabe as an instrument for determining both time and latitude. As an instrument for determining time there is a considerable difference of opinion, even in France, as to its advantages, the remarks made by Mr. Jackson being supported by a similar criticism made previously by M. Renan of the Paris Observatory: in fact, with the theodolite used as a transit instrument one obtains a series of transits, whereas with the prism astrolabe one only is possible. I noticed that in the recent determination of the difference of longitude between Paris and Uccle, Colonel Lecointe gave some figures published in the report of the *Conférence de l'Heure*. These figures show that over the means of each of four evenings of observation there was a range of 0·2ˢecond of time in the determination of the clock error at Uccle. It is only fair to say that this is greatly in excess of the similar determinations made during the fixation of the longitude of Bizerta from Paris, in which the utmost care was taken by highly skilled observers.

As far as regards latitude, I asked Sir David Gill about ten years ago if he was acquainted with the prismatic astrolabe, and what he thought of the method, which is, of course, a very old one. He was of opinion that for latitude in the field it could never compete with the Horrebow-Talcott method. Of course, the latter suffers from the disadvantage that it demands an eyepiece micrometer, but I should personally prefer to have the theodolite fitted with an eyepiece micrometer rather than drag about another instrument, perhaps to the tops of mountains, where even a moderate wind would render the astrolabe useless.

To determine latitude, time, and altitude only three stars are required; so that I cannot see any great advantage in dividing the programme into groups of four stars. Chauvenet, I believe, shows that the conditions are perfect when three stars are spaced 120° in azimuth; one may thus have a time star in the prime vertical, say west, and two latitude and altitude stars, east, at 30° from the meridian north and south. As the authors have pointed out, it is usually impossible to arrange from Almanac stars a proper programme if the altitude be as high as 60°. I used a parallel of 40° of altitude in Fiji, and was sorry I had not made it 30°, in spite of the somewhat greater risk of differential refraction. The theodolite allows unlimited choice in this matter. Some observers favour the almucantar through the pole, which in low latitudes allows of circumpolars being observed not too far from elongation.

The great objection to the method arises from the reduction of the observations; the great advantages are its extreme simplicity in the field, its adaptation to small instruments, and its freedom from instrumental error, excepting that of the level. The great merit of this most interesting and valuable paper lies in the method the authors have employed for simplifying the reductions; this in itself adds to the value of the method.

The Chairman: It is a matter of regret that Colonel Woodroffe is not present to speak in favour of the astrolabe, but I understand he has written to Mr. Hinks, who will communicate the letter to the meeting.

Mr. Hinks: Colonel Woodroffe writes:

"One of the most interesting points is the adoption of the central quadrant stars in preference to the circum-meridian and prime vertical. Dr. Ball states that the centre of the circle is equally well defined in each case, and of course this is so graphically. But are the position lines as accurately determined? It appears to me that for the northing and southing of the circle those stars should be chosen in which a small error in the time will produce the smaller error in altitude: those for the easting and westing, in which a small error in the altitude will produce the smallest error in the clock correction: in other

words, circum-meridians and prime verticals respectively, to get the circle as accurately placed east and west as north and south, about six times as many prime vertical passages are required as circum-meridians. Other stars all round the horizon give corroboration. Naturally this implies more observations, but it seems to me that more precision is gained by this method. One might perhaps state it by saying that, having chosen stars to give the greatest precision of position lines in north-southing, one works up the precision of the east-westing to the same level by multiplying observations. Of course there is the difficulty of obtaining suitable circum-meridians. But if they are obtainable, why not use them? The American Ephemeris used to give many more stars than our N.A. or the French one, and I was generally able to get circum-meridians without having recourse to less well-fixed stars.

"There is one little point I forgot to mention. One of the chief advantages of the higher-powered astrolabe is, I think, that with it one can time the passage of stars near the meridian with so much more accuracy owing to the increased velocity of the images in the field."

Those are the criticisms that Colonel Woodroffe makes. To some extent, it will be perceived that he has given his own case away by remarking that you have to take six or seven times as many prime vertical stars as you do the one rare but valuable circum-meridian star. Colonel Woodroffe is a great enthusiast and one of the few people who has actually worked with the instrument under field conditions. He has used it upon the Brazil-Bolivia boundary survey, having been inoculated with its charms by the French Colonels Mailles and Vincent on the Peru-Bolivia Boundary, so that his opinion is naturally a very strong one.

Major WOLFF, R.E.: I did not see Colonel Woodroffe's paper on the Astrolabe in 1916, as I was out of England at the time and my copy of the *Journal* did not reach me. About a year ago, however, I happened to be quartered at Aldershot with Colonel Woodroffe and I was very interested in what he told me. It seems to me that the great advantage of the instrument is the ease and comfort of the actual observing. To be able to take one's observations seated, with no readings necessary other than the records of time, must be much less fatiguing than reading arc and bubbles on a theodolite, and continually changing face and searching for one's stars, as one has to do in the ordinary observations for latitude by circum-meridian altitudes, and time by altitudes of east and west stars. The smaller and more portable size of astrolabe seems to be more likely to be generally useful. If such a high degree of accuracy were required as would necessitate the use of the larger type of instrument, instruments of precision, such as the zenith telescope, would probably be available.

In all geographical surveys, triangulation and traverses are essentials, so that the theodolite is indispensable, and economy of transport is nearly always of importance, so that it does not seem likely that the astrolabe will be very largely employed, though it may be a very useful adjunct to the equipment of an expedition. There is another point, and that is, that in the comparison of the two instruments mention is made of the fact that the use of the diagonal eyepiece takes away from the accuracy of observations with a theodolite. Why should the diagonal eyepiece take away from the accuracy of the observations? Beyond the fact that it reduces the amount of light, it does not seem to me that it does more than change the direction of the ray.

Mr. HINKS: You have the loss of definition and also a certain danger of disturbing the instrument in reversing.

Major WOLFF: Of course I know it is very difficult to reverse it.

Mr. HINKS: I hope I made it clear that the comparison was with the 5-inch theodolite used at a different elevation in order that they should not use the diagonal eyepiece.

Mr. REEVES: Some years ago the Paris makers were good enough to lend me an *Astrolabe à Prisme* for a short time, which I exhibited at one of our afternoon meetings, and briefly described it, with other instruments, in my paper published in the *Geographical Journal* for March 1913. So far as I am aware, this was the first time the instrument was shown in this country, and although it had been referred to occasionally I do not know of any earlier description of it in English. In my account I endeavoured to arrive at some conclusions as to how it compared as regards accuracy with the theodolite; but owing to the insufficient data I had access to, I did not consider the test very satisfactory, and suggested that a better comparison should be attempted later on. I am therefore specially pleased to learn that Dr. Ball and Mr. Knox-Shaw have undertaken this, but must confess that I am not yet altogether satisfied with the conclusion arrived at as to the relative accuracy obtainable with the two instruments. To take an altitude angle of 60° for the astrolabe and 30° for the theodolite does not appear to me quite fair on the latter instrument. At the comparatively low angle of 30° there is naturally much more chance of irregularities in the refraction of the atmosphere on different sides of the horizon affecting the results than there would be at an angle of 60°, and notwithstanding what is said as to the disadvantage of using the diagonal eyepiece, it seems to me that it would have been better to have used this and kept to the angle of 60° for both instruments. One serious objection to the diagonal eyepiece in ordinary observation work is that it has to be turned round in "changing face," which is liable to disturb the instrument; but this does not apply in the present case, since one "face" is kept throughout. It would at any rate be interesting to see if there is not more error introduced by irregularities in refraction at an angle of 30° than there would be by using the diagonal eyepiece with the theodolite at an angle of 60°.

Then again it seems to me that it would have been fairer to the theodolite if a diaphragm with spider-lines had been used instead of one with the lines cut on the glass; for although there is certainly a chance of their being broken in travelling, there is no doubt that with the spider-lines it is possible to get better results. Many theodolites used on geographical surveying expeditions are fitted with a glass diaphragm, but carry another with spider-lines in addition, in a small receptacle, which can be used when the greatest accuracy is required.

Perhaps what has deterred surveyors who would have employed the equal altitude method more than anything else is the large amount of preparatory work required, and we must all be pleased to hear that Dr. Ball has succeeded in simplifying this. Those who have looked into Messrs. Claude and Driencourt's book on the 'Astrolabe à Prisme' have frequently been dismayed at the apparently complicated and long preliminary computations required, and I agree that this work is not suitable to put into the hands of an ordinary surveyor for ready use in the field, although for previous study it is most valuable. The 'Astrolabe Diagram,' which Dr. Ball has prepared, gives all that is necessary, and by its means one can ascertain beforehand just what is wanted in a very few minutes. We owe a great debt of gratitude to Dr. Ball for the trouble he has taken in this matter, for he has done more than any one else for surveyors to bring this equal altitude method into the more general pro-

minence which it deserves, whether the observations are taken with the prismatic astrolabe, theodolite, or sextant and artificial horizon. The graphic method he gives of the final reduction of the position is extremely interesting and useful.

Mr. HINKS: I am hardly competent, Sir, to take part in the discussion of the paper as if I had been one of its authors. I should, however, like to ask Mr. Jackson whether he actually sees the spectral images that are due to using only a half object-glass. Of course it is well known that there must be such images, but can you actually see any defect in the image?

Mr. JACKSON: Quite distinctly. The images are, perhaps, three or four times as long as they are broad.

Mr. HINKS: It is clearly an important point which Mr. Jackson has raised. For the rest I do not think I can do anything more than, on behalf of the authors of the paper, thank the Society for the favourable response it has received.

The CHAIRMAN: We must all regret that neither the authors nor Colonel Woodroffe were present to speak for the astrolabe, but I believe the instrument has had a fair trial this afternoon. I fear that it must be admitted that it has not come out of the inquiry with its character altogether untarnished; the objection raised by Mr. Jackson that the image is not a point but a line seems to me to be fatal to the astrolabe as an instrument of precision. Before we separate I will ask you to pass a vote of thanks to the authors of the paper and to Mr. Hinks for the lucid way in which he has placed a technical subject before us.

THE ORIGIN OF THE HERERos AND OVAMBO

Professor E. H. L. Schwarz, Rhodes University College

I HAVE recently returned from an expedition into Ovamboland, and though I am not supposed to know anything about native races, a few observations that I made may be of use to those who do. I live among the Kaffirs in Grahamstown, and am in constant association with Xosas and Fingos; I have also travelled extensively in the Native Territory, and know in their homes the Gaikas, Galekas, Tembus, Baklas, Hlubis, Pondos, Pondomisis, and such like, also the Zulus and Basuto. When I entered the South-West Protectorate, I at once felt that I was among natives of a different type altogether. The first suggestion of the view explained in the following note occurred to me when an old gentleman asked me to come to his kraal and drink a glass of beer with him; as he stalked along at my side over the white sand of Ovamboland, I looked at him and said to myself, "Surely this lanky bearded fellow is not a Kaffir or a member of any tribe kin to our eastern natives; he is a Hamite, a Berber from North Africa." Later this idea became strengthened by a number of facts.

The Hereros and Ovambo came south together, and at the Damara tree near Ondonga they separated, the cattle-men, the Hereros, going south and the cultivators going west and north; both are therefore of the same stock. In the men, a large proportion are bearded and mostly tall

and lanky, though towards the Portuguese border they become more stumpy. It is in the women, however, that the most striking evidence is forthcoming. Among the Ovambo the largest tribe is that of the Ondonga, who live in the south. Here the women make long strings of hair from the tails of oxen and stick them on to their heads with pellets of glue, so that they appear to have hair hanging down to their heels; the strings are tied together at the bottom with little wisps of palm-leaf. When at work the women gather the false hair in bunches and tie it up out of their way, but no married woman is ever without her tresses. When we come to the more northerly tribes of the Ovambo, such as the Ombarantu, there is a still more striking development. The women of these tribes make great fat plaits of hair, like the plaits that one is accustomed to see Faust's Marguerita wearing, or that are associated with the women of the Vikings. Sometimes these plaits hang loose down to the waist; in other tribes, for instance, the Ondombothora, the plaits are fixed up under a hat arrangement. In the Ovakwambi, Onganjera, and the Ovakualuthi the hair is plaited in horns, and on the borders of Angola the Ovakuanyama women, who are distinct from their sisters further south, copy them to the extent of fashioning small horns on their heads. Throughout the whole of Ovamboland, therefore, there is a persistent tradition that the women must have some sort of make-belief of having long hair.

The Herero women are long lanky women, the effect being heightened by the Empire dress that they wear, the waist being close under the arms, and from here the skirt sweeps down to the ground. The women about the towns make their dresses of print and anything suitable that they can buy at the shops, but their poorer sisters on the farms have to make shift with rags sewn together; yet it is astonishing how even these manage to reproduce the Empire effect with such materials. For a head-dress every Herero woman has a sort of swollen Liberty cap, made of any rubbish tied up in a kopduk or handkerchief sold specially for the purpose. A lady at Windhuk asked one of these Herero women what she had in her cap; the woman indignantly replied, "The same that you have in your hat." So that in the Hereros, again, we find this make-belief of long hair. Why should the Norseman's helmet turn up in South Africa? Where did they obtain this tribal memory from? Originally the Herero women wore their false hair in the same way as the Ondonga women, and crowned their heads with a Berserker helmet. To my mind the answer lies in the fact that the Hereros and Ovambo were in contact with a white race once upon a time. Indeed, the Ondonga girls when they have their big dance paint themselves pink with the root of a plant. I have the root, and if it grows in Grahamstown I shall be able to identify it. Apart from this point, the Efundura dance is interesting from the fact that at the end the maidens disperse and the bridegrooms have to chase them and carry them back.

This painting of the girls is not a mere ornamentation, like when the Kaffir smears himself with red ochre; it is a definite aping of the white people, dating from long before their womenfolk came in contact with white women from the south. The pretence of long hair, also, means far more than the chignon of the Zulu women or the curls of the Pondo women; it shows that the ancestors of the Hereros and Ovambo were themselves either white people, or were closely associated with white people, and not only so, but that these white people were ruddy and with luxuriant hair; to put it succinctly, the Hereros and Ovambo are the descendants of the Vandals.

The Vandals came originally from Brandenburg and Pomerania, and eventually made their way into Spain. In 428 A.D. Genseric, their king, sailed with the whole nation, numbering 80,000 souls, for Africa, and carved out for himself a kingdom there. In course of time he became so powerful that he was able to take, first Carthage, and finally Rome itself. Genseric was succeeded by a succession of kings, of whom the last, Gelimer, was conquered by Belisarius in 534 A.D. After that, except for an expedition against some remnants of the nation in Africa a couple of years later, the Vandals disappear from history. That they mingled with the tribes of North Africa is certain, since among the Berbers of to-day there may be found individuals with light complexions, fair hair, and blue eyes. It seems a tenable explanation of the origin of the Hereros and Ovambo, that the Vandals retreated after their defeat into the back veld of North Africa, and that, on the drying out of this once fertile region, they came south and filtered through the Negro tribes of Central West Africa. All along the line they intermarried with the natives of the countries traversed, lost their language, their white skins and their hair, but still they carried with them the memory of what they had once been. It seems to me that a tribal reminiscence like that which I have described has the right to be considered along with the language and craniological affinities; the last two are capable of profound modification through intermixture with other tribes. It is a fact, however, that the Ovambo are the only native race in South Africa that can pronounce the English "th"; a pond, for instance, is an "ethea"; and although the Hereros are Bantu and speak a language closely allied to the languages used by Bantu people, yet such a fact can be explained by the common migration of all the Bantu nations from the north and their filtering through the Central African tribes. The Eastern Bantu, to my mind, have strong Semitic traces, derived from their intercourse with the Arabs, whereas the Hereros and Ovambo are Hamitic with Vandal influence. To take one illustration of this difference, the eastern Bantu all circumcise along with the Arabs and Jews, while among the Ovambo circumcision is looked upon as almost equivalent to castration.

There is a negro nation in the Protectorate called the Klip Kaffirs, or Berg Damaras, and just to show how little can the language of these

African tribes indicate their origin, these Klip Kaffirs speak the Bushman language. The Heikum Bushmen, also, the big Bushman, are a Bantu tribe who have adopted the Bushman mode of life and their language.

The Ovambo are an interesting people, quite unspoiled by contact with white men. The Germans were afraid to tackle them, and since their time we have administered Ovamboland with a mere handful of officials, actually, at the present time, three in number. There are several Finnish Missions, but they do not seem to have had much effect on the nation as a whole. There are no traders whatever, and the nearest shop is 200 miles away. The biggest chief is the Ondonga chief Martin, who has accepted Christianity; among other things that he had learnt was the existence of the prophets, so when I came up into his country, he said he was very glad to meet one. We explained that a professor was different from a prophet, but apparently the difference was too subtle to be understood, so we left it at that. Ovamboland is bordered on the west by the Kaokoveld, an enormous tract running to the sea and included in the Game Reserve; it is inhabited by a few Ovatshimba, or degenerate Hereros, under three chiefs, Oorlog, Mahona Katati, and Kasupi. On the north lies Angola. On the east is the Omaheke, or waterless country of white sand, in contrast to the Kalahari, or country of red sand, inhabited by Heikum Bushmen. On the south there is the Game Reserve, consisting of the Etosha Pan and the bare grass flats bordering it; two tribes of Heikum Bushmen live here. The limestone area of Otavi, Tsumeb, and Grootfontein separates the Game Reserve from the Protectorate proper, on the west, with its population of Hereros, Hottentots, and Klip Kaffirs, and on the east, from the Kalahari, whose inhabitants are the true Bushmen.

The above having been shown to Sir Harry Johnston (who once visited Ovamboland), he has written the following criticism, which, while disagreeing with the most striking features of the paper, gives so useful an alternative interpretation of the interesting facts recorded by Prof. Schwarz that we may be allowed to publish the two together.—Ed. *G.J.*

Note on the Foregoing Paper by Sir Harry Johnston, G.C.M.G.

Although the geology, botany, zoology, ethnology, human history, and native languages of the South African sub-continent are but a continuation of the physical geography of Tropical Africa, white South Africans are too apt to consider the regions south of the Zambezi and Kunene as quite distinct from the rest of Africa. There is a peculiar flora in the southernmost parts of Cape Colony and on the high mountains of the Drakensberg; there are a few singularities in the South African fauna (and at the same time some remarkable relationships with the fauna of pleistocene North Africa); but in all essential facts and features, and especially in its human inhabitants of to-day and thirty thousand years ago, South Africa is simply the prolongation of Central and of North Africa.

Had Prof. Schwarz been conversant with the main ethnological facts of Central, East, and West Africa, he would not have propounded the theory of the Vandal origin or affinities of the Ova-hereró, Ovambo, Aandonga, and allied tribes. The "Hamitic" profiles and style of hair-dressing or head ornaments in these South-West African Bantu are not confined to the natives of Damaraland and Ovamboland, but extend into southern and south-western Congoland and eastern Angola. They were noticed markedly by Livingstone in his first great trans-continental journey and are rudely figured in his first book. They attracted the attention of Cameron, Grenfell, various missionary explorers, and of myself from 1874 to the first half of the 'eighties; and much later they are illustrated—intentionally or otherwise—in the superb publications of Emil Torday and Captain T. Athol Joyce.

In the case of the Hereró these "Hamitic" resemblances are—or were—heightened by their long-horned cattle, reminiscent of the *Bos indicus ægyptiacus* of modern Equatorial Africa, of Galaland and of ancient Egypt. But this long-horned breed accompanied not only the Hereró in their march from north-east to south-west, but also the Hottentots who may have preceded them, and who seem to have arisen from a Bushman stock in northern "German" East Africa (south of the Victoria Nyanza), where there is still a form of Hottentot–Bushmen speech in vogue. The Hereró group of Bantu languages extends over the southern half of Angola and thence to Damaraland. It has more affinities with eastern than with western Bantu, and seems to be more particularly related to the languages of the lower Zambezi and of the south-east coast.

The Ova-hereró, the Ova-mbo, and the Ova-kuanyama undoubtedly show that strain of Hamitic (? or Semitic) intermixture in their aristocratic types, which is so marked a feature in the Ba-karanga of Mashunaland, the Kafirs and Zulus of South Africa. This dash of the Hamite recurs in so many of the peoples speaking Bantu languages. It is a striking feature in the Bantu peoples dwelling on the uplands round the great lakes of Equatorial East Africa. Similarly at some period hundreds or a few thousand years ago, the Hamite has mingled with the Nilotic Negro and the Negro of the Sudan. These crosses have produced some of the tallest and handsomest of Negro or Negroid types, giving to many of them long frizzly hair and a fairly full beard. The beards and the facial features of the better-looking among the south-western Bantu which made such an impression on Prof. Schwarz are merely the survival of this ancient Hamitic strain in the Bantu Negroes. They need for their explanation no such far-fetched theory as the migration of the Vandals from the extreme north down almost to the extreme south of Africa, across thousands of miles of desert, impassable forests, or across territories populated by fierce Negro tribes as well armed in those days as the Vandals themselves. The Vandals that disappeared before the conquering arms of the Byzantine Greeks were probably not more than seventy thousand in number. They simply joined

their Berber friends and allies in the high mountains of Western Tunis and Algeria, and may have left their traces there in the tall, brown-haired, grey-eyed Berbers found in the elevated regions of North Africa from Morocco to the interior of Tunis.

The wearing of false hair is very characteristic of the southern Nilotic Negro peoples, those especially that on the north border on Abyssinia and Galaland. The custom appears and re-appears all over Bantu Africa. Undoubtedly it originated in the primitive Negro's admiration for the long head hair of the primitive white man. So also the helmet-shaped coiffure or head ornament. This may be met with in south-western Congoland and other parts of the Congo basin; in West Africa; in Nigeria; in East Africa. Quite possibly ancient Egypt originated the fashion; just as the women of the eastern Sudan—absolute Negresses of the most pronounced type—wear their woolly hair as nearly as possible in the style of the Egyptian sphinx.

The use of the lisping dentals (English *th* and *dh*) is certainly not confined to the south-west Bantu, but recurs over and over again in Negro Africa, West, East, Central and North-East; to say nothing of their presence in some dialects of Arabic and Gala. The eastern Bantu do not all circumcise. The practice has spread very markedly in my forty years' acquaintance with Africa, owing to the advance of Muhammadanism.

Colouring the body with red (derived from mineral or vegetable substances) recurs over and over again amongst the naked or nearly naked Bantu and Sudanic negroes, and the southern Nilotic negroes. In short, there is nothing about the Bantu peoples of South-West Africa which marks them off as having a different origin or affinities from other sections of the Bantu blend of Negro and Negroid which now peoples nearly all the central prolongation of Africa.

The Bantu and Semi-Bantu languages originated in eastern Nigeria some five to three thousand years ago, and may quite possibly have been brought into existence by some determined "white man's" effort to trade with and colonize the region of the north-central Sudan (round about Lake Chad) by a migration across a Sahara less arid than to-day. We have many reasons to suppose that farther back, in the first part of the Neolithic Period, there was a constantly recurring migration of Mediterranean white men across the western Sahara from Algeria and Morocco to Senegambia and the Niger.

Just before the Great War interrupted such work, German ethnologists were at work on a theory supported by numerous archæological discoveries in the north-west Cameroons and Nigeria. They developed the idea that this impingement of the Mediterranean white man on the north-central Sudan (which created the Bantu out of the Semi-Bantu) was derived from a bold enterprise of the Mukenaian or Pelasgian peoples before they had an Aryan tongue imposed on them. Likewise that this movement on Lake Chad and the Benue was quite distinct from Hamitic migrations

eastward or southward from North-East Africa. It is supposed that these Pelasgians spoke a prefix-and-concord-using language with nouns divided into classes akin to some of the Caucasus tongues or the Dravidian or Sumerian; and this Pelasgian white man from Crete and Tripoli, reacting on the Negro speech-forms of the Central Sudan produced not only the Semi-Bantu and the Bantu, but also the Fula, Wolof, and allied "concord-and-class" languages of West Africa.

The Bantu invasion of Central Africa evidently did not commence till about 2500 years ago. The Bantu (and Semi-Bantu) are entirely uninfluenced by the Hamitic and Semitic speech families, except for a few recently borrowed words in East Africa. Similarly, Fula is entirely free from any Hamitic or Semitic influence, except the Arabic terms introduced by Muhammadanism. On the other hand, the Hamitic speech-family *has* reacted on some of the Nilotic tongues in their earlier stages of development; on the Bongo speech of the Bahr-el-ghazal; on Hausa (markedly); and even on Musgu.

These theories (by no means all my own, but put forward by German, French, and British students of Africa) may seem as fragile as that of Prof. Schwarz which I am criticizing. But they have in reality enough support in ascertained facts and recent discoveries to justify me in quoting them as a more reasonable explanation of "northern" affinities in the South-West African Bantu. Finally I might add that there is one further and more prosaic explanation of these "northern" affinities in the Ovambo and kindred tribes, and that is the remarkable infiltration of Portuguese blood through Portuguese halfcaste traders (also an observation of Livingstone's) which has been going on for three centuries.

H. H. JOHNSTON.

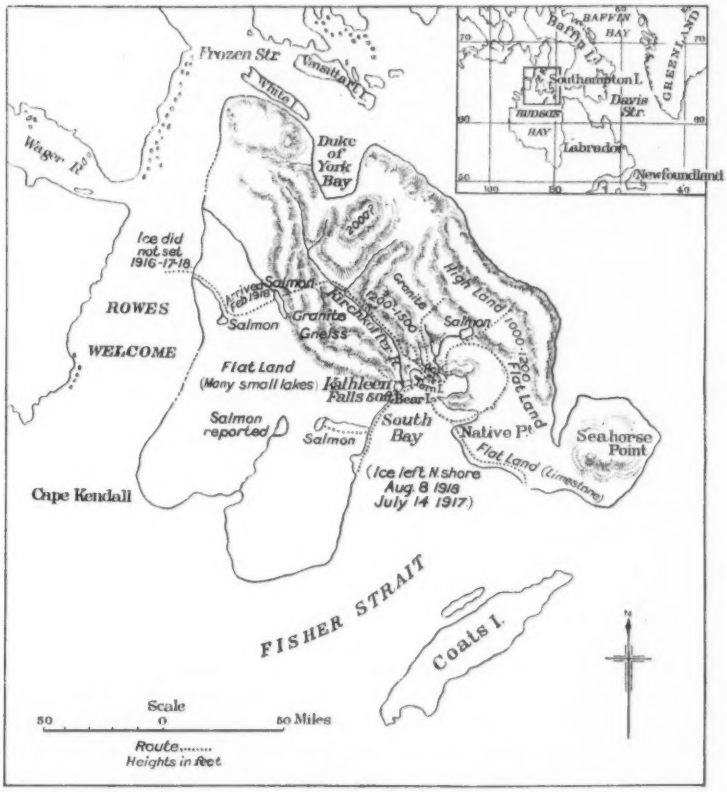
SOUTHAMPTON ISLAND

Captain H. T. Munn

SOUTHAMPTON ISLAND is about 20,000 square miles in extent, and the largest of the group of islands in or about Hudson Bay. In September 1916 I landed there with a small party of Eskimo primarily with the intention of investigating it for minerals, and also to look into its possibilities as a station for whaling, walrusing, and obtaining furs. The winter of 1916–17 was mild, but my ship failed to return for me in 1917, and the winter of 1917–1918 was the coldest of many I have experienced in the Arctic, and also unusually stormy. During the summer of 1917 I made several journeys inland and along the coast, and in February 1918 I took some local natives from my house on South Bay to Rowes Welcome—the western boundary of the island—being the first white man to cross the island, the natives said. My idea was to come

to the mainland, and get south to civilization; this project was frustrated by the moving ice, the strait not setting fast for the third year in succession. Local natives said this was unusual, as they generally crossed every other year.

The only important river on the island is Kirchhoffer river, which I have ventured to name after the late well-known Canadian senator. This runs near Duke of York Bay, and drains a large watershed on its



course to South Bay. About 2000 yards from its mouth is a fine fall, with a sheer drop of 60 feet. The entire highlands of the island are of granitic formation, and the south and south-west coast a very shaly limestone, difficult to walk over, and ruinous to the native-made footgear. Outcrops of granite occur from the mouth of Kirchhoffer river east to the foot of South Bay on the west side.

Salmon ponds are numerous on the island, but the fish are as a

rule small, and of inferior quality compared with those of Baffin's Land, owing perhaps to the extremely shallow waters on the south side of the island. Walrus are numerous in the spring between Coats Island and South Bay, but seal are very scarce, and as these last are necessary to the natives for clothing and blubber, their absence caused some suffering among the party I brought there. White whale are scarce, and no "right" whales were seen during my stay. Arctic foxes were scarce in 1917, and plentiful in 1918, the reverse being the case with polar bear, of which I obtained over one hundred in the winter of 1917–18, and only a dozen the following winter. The non-arrival of my ship in 1917 ran me very short of coal, and I got through the winter of 1918 on two thousand pounds and a few oak barrel-staves, an experience in fuel shortage not worth repeating.

Perhaps the most exciting incident of my stay was an attempt I made, after many efforts, to obtain a motion picture of the native dogs "holding up" a polar bear. They failed, however, to engross his attention when I arrived with my camera, and a most determined charge on his part was only stopped a dozen paces away by a lucky shot. Some of these big bear are as fearless as others are cowardly, and I had unluckily run on one of the former.

Cariboo are plentiful on Southampton Island, wintering on the high tablelands, and summering on the low lands near the shores, where the sea breezes gave them relief from the mosquitos. I obtained a few interesting relics, such as flint harpoon and arrow heads, a walrus tusk sled, a copper-bladed woman's knife, some bone needles, and crude wooden carvings of women, children, and dogs.

The original inhabitants of this island were the Sead-ler-mee-oo tribe, known to Parry and other early explorers, and always referred to by the other tribes as the "strangers" owing to their exclusiveness. About twelve years ago they all died of a disease which sounded like typhoid. They were one of the most interesting of the "central" Eskimo tribes, being distinctive in dress and customs. One of their memorials on the island consists of two rows of carefully built-up stone pillars, in which some very large stones are used; the pillars are about 10 to 12 feet high, and both rows—though several miles apart—run about north and south. The local natives (from the mainland), although many of the older had visited the tribe in former years, could give me no satisfactory explanation of them, nor had they ever seen them used for any purpose. A vague suggestion by one old man that these pillars had to do with "spirits" hinted of some religious significance, though I was quite unable to confirm this, and they had no connection with any burial-place, numbers of graves being found at other places, but none near these pillars. The Sead-ler-mee-oo wintered in dug-out circular igloos, roofing them with whale ribs and large flat stones and sod. They never used the snow igloos—and hardly knew how to build them, I was told. As polar bear were plentiful

and dangerous, but they had no firearms, they often attacked and killed the bear with lances if they had a few dogs to assist them. Walrus was their staple food, and they seem to have been intrepid hunters of these the most dangerous of all polar game when tackled without firearms. It is an interesting fact that their dress—bearskin knickers for the men and a distinctive dress for the women—closely resembled the "Polar" Eskimo of Smith Sound and Etah, pictures of whom were at once recognized by the older men to whom I showed them. Is it possible this is a clue to Rasmussen's interesting Eskimo story of a migration?

On the arrival of my ship in the summer of 1918, I abandoned Southampton Island and returned my natives to Baffin's Land. D.O.R.A.'s far-reaching hand has touched even these Arctic denizens, for the Food Control allowed such limited supplies on my vessel that I was unable to reach a white man I had left in charge at the northern end of Baffin's Land, and he and the natives with him have had to get through another year without supplies or ammunition.

REVIEWS

EUROPE

Luxemburg and Her Neighbours.— **Ruth Putnam.** New York and London: Putnam's Sons. 1918. Pp. xiv., 484. *Maps and Illustrations.* $2.50.

In this volume the authoress continues the methods of historical investigation which she has already applied to Alsace and Lorraine. It is a little disquieting to geographers to find the purely geographical description of the land compressed into seventeen lines of an introductory note, but the changes of frontier at successive periods are fully worked out and illustrated by a map, and their relative political values are indicated. The book is eminently readable, and it is brought down to date in respect of the position of Luxemburg during the war, and the circumstances under which its territory was violated by German forces; here again a sketch-map illustrates. Numerous illustrations from old prints are furnished, and some of these are not without topographical interest. A notice on the cover applies to this little territory the phrase "a land without a country," which, though perhaps hardly to be justified by the dictionary, conceals a certain geographical significance pointing to the somewhat anomalous position which independent Luxemburg has occupied—a position which must be taken into account in determining its future. It has failed through no fault of its own in the function of a buffer State; the springs of the buffer need strengthening, and this is a geographical problem which the present volume certainly helps to elucidate. O. J. R. H.

ASIA

A Broken Journey.— **Mary Gaunt.** London: T. Werner Laurie. 1919. 18*s. net.*

This is a chatty, entertaining book of travel, and the author's description of her journey in Shansi gives us glimpses of rural Chinese life and of the pathos of the foreign missionaries' exile which are seldom vouchsafed us. However, it would be misleading to count it a serious book of travel, and those who look

to it for matter of a general and informative nature will be disappointed. Since the latest authoritative reports of Manchuria and Eastern Siberia to hand date from 1912, many of us would give much to know the changes, political, administrative, and social, which took place in those countries during the years previous to the outbreak of war. Perhaps it is hardly fair to expect such from one who confesses to the membership of a family subject without warning to attacks of *wanderlust*, and most travellers will admit regret that they had read so little, before starting, of the countries they were about to visit.

The journey in China was not without danger, and the author was repeatedly warned of the activities of the robber chief, White Wolf, yet she pressed on in face of danger, attended only by Chinese servants, until it became madness to go further ; and then reluctantly turned back within sight of the Shensi hills. Having failed to traverse Western China, Tibet, and Turkestan, on the way to the Russian terminus of the Trans-Caspian railway, she determined to cross Siberia, which she did, not merely by a through journey from Pekin or Vladivostok, but by making her way north-eastward to the mouth of the River Amur before turning westward.

Leaving Tientsin by train for Kharbin, the author proceeded eastward to Vladivostok, and thence north to Khabarovsk on the Amur by the Ussuri railway (not new, as is stated on p. 165, but completed more than twenty years ago). Turning eastward again the river was descended to Nikolaievsk, and a flying visit paid to the ill-omened island of Sakhalin. The journey to Europe was made by the usual means before the recent completion of the Amur railway, *i.e.* by steamer for 2000 miles to Stretyensk and thence by train to Petrograd. Incidents of the trip are humorously depicted, and, war having broken out in Europe while the author was yet on the Amur, the journey from that point was certainly not monotonous, and from Petrograd to England became both devious and exciting.

We miss the broad outlook of the student and traveller, but it must be admitted that the Russian Empire is not an easy country in which to glean information. The obvious barrier is the unfamiliar language, and to this is added Russian exaggeration, ignorance of affairs, and a politeness which lends itself to pleasing rather than true statements. Misinformation is bound to creep into the best of books, and we think in fairness to the Japanese there should be set against the Russian officer's report of the Japanese destruction of the small ethnographical museum at Alexandrovsk, Sakhalin, the *Times* telegrams in July 1905, which told of its being fired with other buildings in a panic by the retreating Russians or exiles, on the approach of the Japanese.

To one who has stayed at the same hotel in Khabarovsk it scarcely seems possible that the author could have descried thence the confluence of the Ussuri and the Amur Rivers 29 miles above the town, and while the author would probably be the first to disclaim accuracy, there is one exception where she tells us that the "right name of the Chinese town" opposite Blagovyeshchensk is Sakalin. May we beg to differ? It is a Manchu town named Sahalien, meaning black, the name given to the River Amur (which the Chinese call Hei-lung-kiang, or black dragon river), and the Russians get very near to it with their pronunciation, the English equivalent of which is Sakhalin. Naturally the uneducated Russian talks of it as Sakalin. War typography, we suppose, must be held responsible for the spelling of Kodbo, Davos Platts, and Baron Reichthoffen, but we hasten to say that the inhabitants of Vladivostok will be grateful to the author for the omission of the letter "C" from the name of their town, the inclusion of which is a particular source of annoyance to

them. Less happy is the spelling Kamscatkha, but here the author sins in good company. Why should otherwise learned Britons borrow their transliteration of Russian names from the Germans and then mispronounce them? The Russian name of the peninsula is well rendered by the English Kam-chatka, but we at one time borrowed the German *sch* and then ignorantly split it in two, calling the country Kams-katka.

Putting aside the critic's cap, however, the reader will travel easily and amusingly over vast distances in the good company of the author, and travellers will echo her gratitude to the many kindly disposed and helpful strangers met with in the course of travel. C. H. H.

AFRICA

The Bantu Languages.— **Alice Werner** (Reader in Swahili, etc., School of Oriental Studies, author of various previous works on African Linguistics, Ethnology, etc.). London: Kegan Paul, Trench, Trübner & Co. 1919. *Price 7s. 6d.*

In this compact, cheaply priced, clearly printed volume, Miss Werner gives to her students and to the reading public generally an excellent initiation into the Bantu languages. She takes chiefly for her general exposition of the speech family the Luganda, Swahili, Ronga, Zulu, Herero, Kongo, and Duala languages, and from out of a comparison of their respective features in construction, syntax, and phonology she leaves in the mind of the attentive reader a very clear impression of the general form of the typical Bantu language, as well as the lines of variation and of specialization followed by the main divergent groups of the East African, the South African, the South-West, and the West African Bantu. If she had wished to make her book a more ample treatise she could have done so out of her own stores of personal research had she not displayed a rare spirit of self-denial. For a number of years past—our Bantu acquaintance and collaboration dates from 1891—she has collected information regarding the vocabularies of Bantu and Hamitic languages which might serve for her present reviewer's work in two volumes on the 'Comparative Study of the Bantu and the Semi-Bantu Languages'; and knowing that the publication of the first volume of his 'Comparative Grammar' was imminent, she has not included a portion of her researches in her own book, but has confined it in scope to the purposes above cited. Consequently—if it be permissible to drop into the more convenient first person—her 'Bantu Languages' covers very little of my ground, yet supplies the student with information outside my range. The main purpose of Miss Werner's 'Bantu Languages' is the practical one of assisting young men and women to learn to speak and effectively to use one or more Bantu languages; my motive in my two volumes has been to illustrate the features of the whole of the Bantu and Semi-Bantu languages (so far as they are known), and to trace out the unwritten history of West and Central Africa which is locked up in their word-roots and syntaxial forms.

Miss Werner's book brings home forcibly one of the chief points of interest in the Bantu languages—the remarkable similarity in their syntax and even in their roots of verb, numeral, noun, and adjective throughout Central Africa, from the Cameroons to Natal and from the sources of the Nile to Damaraland. Learn one Bantu language thoroughly and almost any other can be readily acquired. Their political importance rests on the fact that with the negligible exception of Hottentot and Bushman and a few patches of unclassified tongues in East Africa and the Northern Congo, the Bantu is the only language family of all Central Africa, south of Nigeria and Somaliland. The resemblances

between one Bantu group and another are more evident than the kinship between the different groups of Aryan languages. The resemblance between Bantu and Semi-Bantu is nearly the same as between Semitic and Hamitic. Miss Werner, by the by, either directly or indirectly, shows that there is absolutely no Hamitic influence on the grammar or vocabulary of the Bantu languages, however much the Bantu physical type may have in one part of Africa and another been created by an ancient mingling in blood between the Hamitic Negroid and the Bantu Forest Negro.

The appendices to her book are as important as the main treatise, and are eminently practical in their clear and patient exposition of the principles on which the Bantu languages are constructed. I am obliged to disagree with her on a few points (of no importance to the student who wants to learn to speak these tongues) concerning the enumeration of the less-known prefixes, in which she follows Carl Meinhof, and in regard to Bantu phonology and the primitive consonants and vowels of the mother Bantu tongue. These matters are fully discussed in the second volume of my 'Comparative Study.' I share with her —fully—the exasperation one is entitled to feel at the slow progress of my work through the printing-press, but this is partly due to the delays caused by the war, and—worst of all—to the lack of funds of the Oxford University Press, to which the production of the work has been as costly as it has been to its unfortunate author. Probably before this review is in print the first volume of my 'Comparative Study' will be available to the public, and it will then be seen how considerable a part Miss Werner has played in Bantu studies by the collection of material for discussion, as well as by writing the book under review, and by her previous translations of Carl Meinhof's theories on the inter-relationships of African languages. H. H. JOHNSTON.

Through Egypt in War-Time.— Martin S. Briggs. London: T. Fisher Unwin. 1918. Pp. 272. *Illustrations and Sketch-map.* 21*s. net.*

Mr. Briggs, by profession an architect, found himself during the war a captain in the R.A.M.C. and a sanitary officer attached to the Egyptian Expeditionary Force. It was his duty to visit all the military camps in Egypt, and he went from Sollum to the Wadi Ghuzze, and from Alexandria to Assuan. There is naturally a strong flavour of soldiering in the book, but it is not with military events that the author deals. He tells us what he saw, mostly and wisely dealing with his experiences in the less and little known regions. As he brought with him a considerable knowledge of things Egyptian, and as he possesses an observant eye and a pleasing gift of narration, the result is a volume of interest and value. It does not deal with the Nationalist movement, but there are references to the condition of the fellahin in Upper Egypt which are illuminating.

To the geographer the chapters most attractive are those concerning the Libyan coast and the oases of Siwa and Baharia. Mr. Briggs's description of Siwa and its people is the most recent we have, and well repays attentive reading. The topography of the Libyan plateau is also clearly brought out, and there is some account of its peoples and the trade with the Sudan they still maintain. Why Mr. Briggs calls the Walad Ali the "Auladali" is not clear. The author quotes, with effect, from the book of Herr Ewald Falls, who in 1905-7 did archæological and exploring work in these regions, to show that Germany was even then intriguing with the Senussi against England, and he has other pertinent references to German methods in Egypt. (Yet the index does not mention Germany.)

The value of the book, which deserves to be widely read, is added to by the many sketches by the author it contains, and also the photographic illustrations. There are a couple of sketch-maps. One of them shows the little railway intended to go to Baharia oasis, but which stopped halfway.

F. R. C.

GENERAL

Life of Frederick Courtney Selous, D.S.O.— **J. G. Millais, F.Z.S.** London: Longmans, Green & Co. 1918. Pp. xii. and 387. 21*s. net.*

Mr. J. G. Millais's 'Life of Frederick Courtney Selous' is a praiseworthy piece of work. It gives us a true picture of the great hunter-naturalist, the pioneer and explorer of large tracts of South-Central Africa, the gallant gentleman who fell at last fighting for his country in East Africa. An outline of Selous's career and some appreciations of his character have already appeared n the *Journal* (vol. 49, pp. 221–226), and it is not necessary here to go over the record. Selous was a great man, modest and lovable, and his name and fame are not likely to perish. Among the African tribes who knew both, he ranks with Livingstone—his own earliest hero.

The book before us has its limitations. Mr. Millais makes no attempt to describe Selous's contributions to geographical knowledge, and there is no map, while we miss particulars of his home life in later years. Naturally as a big-game hunter himself, the author deals fully with Selous's hunting adventures, not only in Africa but in Canada, the Rockies, and wherever he went. These chapters contain many good stories, and by all sportsmen will be read with close attention.

To the non-sporting reader the opening and closing chapters of the book make the strongest appeal. Few pages have proved more fascinating to the writer of this notice than Selous's own account of his life at a preparatory school and at Rugby, which is given in Chapters I. and II. They are most excellent, and they prove that, had he chosen, the great hunter might have gained fame as a writer of schoolboy stories. Then the closing chapters tell of Selous's services with the Legion of Frontiersmen in East Africa. It was not the first time he had seen war, for he had been on active service in the Matabele campaign, but he was well over sixty-two in August 1914, and might justly have been content with the special constable's work he at first undertook. But his keenness prevailed, and he reached Mombasa in May 1915. We are given Selous's own accounts of the Bukoba expedition and of other incidents of the campaigns, which they help to elucidate. He was killed in action in the Rufiji region on 4 January 1917. "Who could," wrote Mr. Roosevelt, "wish a better life or a better death, or desire to leave a more honourable heritage to his family and his nation?"

The inscription on the frontispiece gives the date of Selous's death as January 6, and once or twice the same error is repeated in the text. His eldest son was killed in France in January 1918, and in this case again Mr. Millais gives both the 4th and 6th as the date. The matter might be put right in later editions, which will be called for if Mr. Millais's fine memorial of his friend has the circulation it deserves.

F. R. C.

THE MONTHLY RECORD

EUROPE

The Port of Rouen and the War.

IN virtue of its position relatively to the military operations in Northern France and to the centres of industry in the same region, the port of Rouen played a part of unique importance during the war, which has caused the amount of tonnage entering it to increase by leaps and bounds. The whole of its recent history as a port of entry for Northern France is well summarized in the *Annales de Géographie* for March 1919 by M. Alfred Uhry, who has made a special study of the question during the last four years. Even before the war Rouen was taking a more and more important place among French ports, having attained a volume of trade which left it second only to Marseilles, and far in advance of the third port, Bordeaux. Even in 1913 imports constituted 92 per cent. of the total movement, Rouen being the chief port of entry for coal, timber, wine, cellulose, and petroleum. By 1917 the imports had reached 99 per cent. of the total trade, and, at the imposing figure of 9,500,000 tons, left far behind Marseilles with its 4,500,000, this last having itself fallen considerably behind Havre, which the conditions due to the war had raised from the fourth to the second place. It is of course recognized that the causes of this enormous increase in the activities of Rouen have been exceptional, but in view of the period of prosperity which had opened before the war, and the great impetus towards new developments given by the latter, a prosperous future seems assured. M. Uhry passes under review the several steps that had been taken, starting from 1846, to improve both the navigation of the lower Seine and the wharf accommodation at Rouen itself. They had done much to meet the yearly increasing needs, though never quite able to keep pace with the latter, and only in 1913 large sums had been voted to further improve the facilities for dealing with the trade of the port, both maritime and riverine. On the latter side it had shown an advance equally striking with that of the external trade, having risen from 875,000 tons in 1893 to 3,780,000 tons in 1913. The industrial development of Rouen had likewise proceeded apace, and this in turn had led to a greatly increased demand for English coal, which entered in increasing quantities both for local use and for the supply of the Paris region. During the war the enormous influx of military supplies for the French and British armies rendered necessary huge efforts to improvise means of accelerating both the movements of vessels and the operations of unloading, etc. They seem to have been extraordinarily successful, and the results exceeded all expectations. Large additions were made to the number of tugs, lighters, and so forth, and new wharfs and warehouses were provided along the banks of the river both above and below Rouen. The river transport was so organized as to set free the railways for military needs, and the total tonnage forwarded by this means, which reached a total of 5,000,000 tons in 1915, had mounted in 1917 to over 7,000,000. Already steps have been taken to provide a fleet of tugs and lighters of an improved type, and to reconstruct the bridges which impede navigation in times of flood. The enormous impetus given to the industrial development of the whole region will, it is thought, have permanent results, and the energetic merchants of Rouen are already contemplating the opening of new commercial relations abroad, notably with Morocco, West Africa, and Indo-China.

ASIA

The Himalayan Problem.

In a recent official publication of the Survey of India (Professional Paper, No. 17 : " Investigations of Isostasy in Himalayan and Neighbouring Regions " 1918) Sir Sidney Burrard makes a further step towards the solution of the Himalayan problem. The principle of isostatic compensation has been investigated mathematically in so far as it applies to " topography," that is to the visible and measurable departures of the Earth's surface from the ideal spheroid. To apply it to the variations of rock-density is a more difficult problem, since the depth to which any given rock descends can rarely be determined with accuracy. This however is what Sir Sidney Burrard attempts, beginning with the comparatively simple case of the Gangetic trough with its filling of material of low density. Assuming that this light material is compensated by denser material below, pendulum observations over the trough should show a deficiency of gravity, since the lighter material is nearer than the denser. But at stations north and south of the trough the case is different : " A pendulum is actuated by the vertical component of gravity : the vertical component due to surface rock deposits, situated in a horizontal direction to one side of the pendulum, will be very small, but the vertical component of the compensation rocks situated at a great depth will be considerable." Now the gravity anomalies (after allowing for " topographic " compensation) are actually negative for places situated over the trough, and positive for those north and south of it. There is therefore a *primâ facie* case for the Gangetic trough being compensated. But are these " residual anomalies " of the right order of magnitude, as well as of the right sign ? This can only be determined by calculating the dimensions of the trough that would give such results, and considering whether those dimensions are probable. Assuming a density of 2·4 for the rocks of the trough, the calculation makes the trough on the average 120 miles wide and 50,000 feet deep. (Further calculations on a basis of other densities than 2·4 are desirable.) This is a depth double that of the Tuscarora trough (though we do not know how far that deep is filled by sediment) and far exceeding the maximum height of the Himalayas (though here again we do not know the extent of denudation). Whether such dimensions are probable is a question on which Indian geologists must express an opinion.

Sir Sidney Burrard also deals with other areas more briefly, the observations being fewer. The most instructive of these is that of the Satpura range, which affords converse conditions to those of the Gangetic trough, the surface rocks (Deccan trap) being abnormally heavy. Here also the gravity anomalies are conformable to the theory of compensation. The paper is illustrated by a coloured orographical map, a map showing the observation-stations, a section to true scale across the trough, and an abundance of tables.

AMERICA

Mean Sea-Level and Precise Levelling in Canada.

In the February 1919 number of the *Journal* of the *Engineering Institute of Canada*, Dr. W. Bell Dawson, Superintendent of Tidal and Current Surveys, Canada, discusses " Mean Sea-Level as a general datum for Canada." The paper deals first with the results obtained for determining mean sea-level at the Tidal Stations on the Atlantic and Pacific Coasts, and secondly with the network of precise levelling throughout the Dominion and the connections of the levelling with the tidal stations. Dr. Dawson appeals, through the Institute, to

engineers in Canada to abandon the practice of adopting an arbitrary datum, and asks them to adopt mean sea-level for all new undertakings. The Superintendent of the United States Coast and Geodetic Survey made a similar appeal in 1917 to U.S. engineers in a paper on "The Use of Mean Sea-Level." The Dominion of Canada is so well equipped with Tidal Observatories, and the tidal observations have, with great foresight, been kept so well ahead of the precise levelling, that there is no reason why Dr. Dawson's very sensible appeal should not be acted upon, with the one exception he mentions of marine charts, where a local low-water datum is preferred by sailors in order to avoid negative corrections, and to show the least amount of water available for vessels entering ports. The Tidal Observatory at St. Paul Island, though useless for connection with the precise levelling on the mainland, is admirably situated for investigations into tidal phenomena of the Atlantic. Hourly readings of the height of the sea above the zero of the gauge at St. Paul Island have been taken since 1903, and, with slight breaks, since 1895. The information which is being obtained from this tidal station should prove of great value in determining the periods and amplitudes of tides of long period. Tides of long period are certainly indicated from the records of St. Paul Island, and every year's records now will render the present results more valuable.

It will also be possible to study the relationship of the annual rise or fall above the mean on the Canadian side of the Atlantic and on the coast of Great Britain. The records of the Ordnance Survey tidal stations at Newlyn and at Dunbar do not however yet extend over sufficiently long periods for comparison, as the observations were begun at Newlyn only in 1915, which is the latest year for which the results at St. Paul Island are published.

Dr. Bell Dawson's statement that the average of the determinations of mean sea-level for three or four complete years must be regarded as correct is to be read in relation to the levelling of Canada, and not to the general problem of the precise determination of mean sea-level. The regulations for the precise levelling of the Dominion allow a probable error, as derived from the difference of the forward and back levellings, of $0{\cdot}017\sqrt{M}$ feet, where M is the distance levelled in miles, so that for 100 miles of levelling the probable error is 0·17 foot, which is more than the variation from the mean of mean sea-level calculated from fifteen years' observations at St. Paul Island. With a probable error per mile of $0{\cdot}004\sqrt{M}$ for all errors, accidental and systematic, which is the standard of the Indian and British Geodetic levelling, a mean of three or four years' tidal observations could not be regarded as "absolute."

As a matter of fact, the precision of the Canadian levelling appears to be considerably greater than the limit allowed. A large part of the transcontinental levelling across the prairies, being only a single line, cannot be closed in circuits in Canadian territory, but, where circuits have been closed, as in British Columbia, Ontario, and the Maritime provinces, the precision appears to be much better than the limit allowed. For example, the closing error of the circuit Toronto—Owen Sound—Hyde Park—Hamilton, a distance of 420 miles, is 0·16 foot, which gives a probable error of only $0{\cdot}005\sqrt{M}$. It is not known whether orthometric or dynamic corrections are applied, but, the general direction of the levelling being east and west, these corrections would in any case be small. Considering the great speed reached in the precise levelling, the accuracy is of a high order. The levelling is done almost entirely along railway tracks, using the rails as turning-points. The levellers and their instruments are transported on railway motor-cars, and the men live in camps, moving camp about every 15 miles. Work in the field is only possible

for six months in the year. In the year 1917 each party averaged 250 miles of double levelling in the six months. The precision obtained tends to show that speed is one of the most essential factors in securing accuracy. The precise levelling of Canada is connected with the United States system and the New York tidal station through Rouse Point and other points common to the two surveys, but this fact, though of value for comparison of results, is not a necessity to the Canadian Survey, which, with its numerous tidal stations, both on the east and west coasts, and the good connections between the tidal stations, is a completely self-contained system that is developing with great rapidity, and at the same time maintaining a high standard.

A. J. WOLFF, Major R.E.

The San Salvador Earthquake of 28 April 1919.

Writing from Los Lagartos in the republic of El Salvador on 17 May last, Mr. Cecil J. Wacher, to whom we were indebted for a graphic account of the disastrous earthquake in that country on 17 June 1917 (see *Journal*, vol. 50, pp. 236, 304), makes reference to the still greater catastrophe which overtook the city of El Salvador at 1 a.m. on 28 April of this year. On the latter occasion, he says, there were many more deaths, and although the exteriors of houses recently constructed of *deployé* or *hynib* and cement showed less signs of ruin, the interiors were even more greatly damaged, and in the suburbs where the houses are still of the wattle and daub variety the wreck was complete. It is remarkable that the whole disaster was limited to an area within a radius of 10–12 miles; within this space, which had the city for its centre, there was almost total destruction, but outside it there was no damage at all. Mr. Wacher says that the crash of falling buildings mingled with the shrieks of the people, the dense clouds of dust and almost total darkness made a scene which it is quite impossible to forget. Fortunately there was no volcanic eruption to add to the terror, but the shocks of lesser intensity continued every three or four minutes throughout the night. At the time of writing the Earth seemed to be settling down to the normal, though there were still several shocks daily.

MATHEMATICAL AND PHYSICAL GEOGRAPHY

"Continentality" and Temperature with Special Reference to Glaciation.

In a paper published in the *Quarterly Journal of the Royal Meteorological Society* (vol. 43, 1917, p. 159), Mr. C. E. P. Brooks has shown how for a narrow belt of latitude between 40° and 60° N. in the Eurasian continent the winter and summer temperatures can be reconstructed from the altitude, the amount of heat received from the sun, and the percentage of land in a circle of suitably chosen radius surrounding the locality—the last factor being designated the "continentality" of the region. In a second paper in the same journal (vol. 44, 1918, p. 253), the author has worked out the general variations with latitude of the continentality coefficients, and the two papers form a striking contribution to the subject. Brooks utilizes data from many different parts of the globe, and for each latitude finds the relationship of temperature to land to the west when land to the east and ice covering are supposed constant, and similarly for land to the east. The geographical meaning of the mathematical discussion is indicated by such results in connection with the coefficients of land percentage as the following: (1) In winter the effect of land to the west is in nearly all cases to lower temperature; (2) in winter the effect of land to the east is almost negligible; (3) in summer the general effect of land whether to

east or west is to raise temperature, though the effect is nowhere so great as the opposite effect in winter.

The details of a discussion so intricate must be sought in the original papers, and we can here only refer further to the special interest of the investigation in regard to the theory of glacial periods. On the basis of the calculated temperatures of water and land hemispheres, a method is obtained of examining the climatic effect of changes in the land and sea distribution, and it is shown that the changes of form which the Earth has undergone are alone quite sufficient to account for such oscillations of climate as are implied by periods of extensive glaciation. Starting from the period immediately preceding the last or Quaternary glacial period (which was the culmination of a great period of elevation in cold temperate regions with corresponding depression in the tropics), Brooks traces the differences in level and in land and sea distribution between that time and the present, showing that the temperature must formerly have been low enough to permit the development of extensive ice-sheets in North America, Europe, and Asia north of 50° N., the conditions attendant upon such glaciation in high latitudes leading to increased precipitation in warm temperature and tropical latitudes. But the load due to the ice-sheets resulted in a disturbance of isostatic equilibrium, so that the land subsequently sank, with increase of temperature and disappearance of ice, to rise again later with reappearance of ice, the process being repeated four times. Light is further thrown on the warm Tertiary period, and it must be admitted that this closely reasoned attempt to explain, on the basis of geographic changes alone, the warm and cold epochs which geology demands, is a promising alternative to previous astronomical speculations. Geologists may, it seems, gradually be enabled to define the position of our own epoch in the system of climatic evolution.*

The Earth's Interior.

A summary of the results of recent investigations on the constitution of the Earth's interior is contributed to the *Geological Magazine* for January 1919 by Mr. R. D. Oldham. After reminding us that the old arguments based on the temperature-gradient no longer hold since the discovery that the radium in the crust is sufficient to account for that gradient, he proceeds to show what has been learned from observation of earthquake-waves transmitted through the Earth at various depths, since he first called attention to this evidence in 1906. His conclusion is that there is a twofold chemical and a threefold physical division of the Earth's substance. The former is the well-known division into an outer "stony" shell, with density about 3, and a metallic nucleus with density about 8—the limit between the two being about a quarter-radius depth (1400 kms.), as indicated by a retardation of earthquake-waves which pass that limit. The physical division is into a rigid "crust," a middle "asthenosphere," practically rigid to all stresses except those of long duration, and a central nucleus effectively devoid of rigidity since distortional waves which enter it are lost. The limit between the first two is placed at about 30 kms. depth, and forms a surface from which earthquake-waves are reflected internally. The limit between the second and third is placed at about half the radius, as

* It may be recalled that the same author in an earlier paper (*Q.J.R. Meteor. Soc.*, 40, vol. 40,1914, p. 53) discussed the great importance in the general circulation of the atmosphere of glacial anticyclones, such as to-day dominate Antarctica and Greenland, but which at the epochs of maximum glaciation must have covered much more extended areas. The theory of glacial anticyclones had already been elaborated by Hobbs in his 'Characteristics of Existing Glaciers,' published in 1911.

indicated by the absence of a "second phase" in seismic records when the wave-path emerges at more than 120° from the epicentre.

GENERAL

The Hakluyt Society.

A leaflet inserted in the present number calls attention to the work of this active Society, which deserves to be more widely known than it is among those interested in the history of geography and travel. Throughout its existence of now more than seventy years the kindred interests of the Hakluyt Society and of our own have led to close relations and cordial co-operation between the two, and we are glad to give such aid as we can in making known its claims to support by our Fellows. As is shown by the present leaflet the activity of the Hakluyt Society is being well maintained despite the difficulties caused by war conditions, and the list of recent and forthcoming volumes gives no indication of any lack of material for many years to come. The latest issue—the new edition of the Book of Duarte Barbosa—was recently reviewed in our pages (April 1919, p. 280), and is a striking example of the enhanced interest afforded by such a work when elucidated by an editor so competent as Mr. Longworth Dames. The continuation of the travels of Peter Mundy, of which two volumes have already appeared under the capable editorship of Sir Richard Temple, seems likely to surpass in interest the earlier journals of this active and industrious traveller, whose routes covered an extraordinary amount of ground both in the Nearer and Farther East during a large part of the seventeenth century. Until their publication was undertaken by the Hakluyt Society some fifteen years ago these journals had remained in MS., and they are thus being made generally accessible for the first time. The volumes still to appear will deal with the Far East at a time for which comparatively little authentic information has been available in published works, in English at least, and their value will be increased by facsimile reproductions of the large number of original drawings by the author of the journals. Sir Everard im Thurn's volume on Fiji in the early days of the nineteenth century, also from a previously unpublished MS., opens a field hitherto untouched by the Society, which has as a rule devoted its attention to earlier periods. We believe that the editor and his coadjutors have brought to light much interesting information on events in the Pacific at a period about which existing literature is scanty—largely in connection with forgotten voyages in quest of sandalwood. Mr. Corney's forthcoming volume on Tahiti will complete an important series of records of the Spanish relations with Tahiti in the eighteenth century, and is of special interest to our Society from the fact that the translation which will occupy the bulk of the volume is made from a unique MS. preserved in our own library. As all the funds of the Hakluyt Society are devoted to its publications, its output is directly proportional to the number of its members. It has naturally felt the prejudicial effects of the war as have all other bodies of a like kind, and it is hoped that a large addition to its membership will enable it to go actively forward with the important tasks still waiting to be done.

CORRESPONDENCE

Physical and Strategic Geography of the Adriatic

I HAVE the honour to ask you to be good enough to publish this brief note in reply to the address of Commander Roncagli which appeared in the April

number of the *Geographical Journal*. It is not necessary to enter into any discussion of the details of the Commander's address at this time. Italy's claims to domination of Jugo-Slav peoples and lands on the east coast of the Adriatic, claims which Roncagli seeks to support by geological and botanical arguments, are before the world; and the world will render its judgment, not on the basis of identity between the rocks of Ancona and Gargano in Italy and those of Dalmatia in Jugo-Slavia, or on other such quaint arguments, but on the basis of that right, justice, and spirit of fair play so dear to the British heart.

It is necessary, however, that I should protest against the methods employed by the Commander in presenting his arguments. He quotes and criticizes the illogical methods of certain German geographers, notably Penck; asserts that my methods are similar; and thereby deduces the remarkable conclusion that I must favour the Po as the northern frontier of Italy, and other conclusions equally absurd. It is hardly necessary to state that I never entertained or expressed any such ideas. Nor have I ever prostituted my science to proving that the natural boundary of the Balkan Peninsula lies west of the Isonzo so as to include the ancient Slavic region about Udine.

Here is what I have written in the *Geographical Review*, published by the American Geographical Society of New York (vol. 5, No. 5, May 1918):

> Numerous Italian writers have attempted during the present war to show that the natural frontiers of Italy on the east are not the well-known frontiers of the Apennine Peninsula. These natural frontiers, so say these writers, include part of the Balkan Peninsula as far as the divide between the Adriatic drainage and that of the Save, so that a large part of the Dinaric region as far as the highest range would, from the geographical and natural point of view, belong to Italy. These are also, so they say, the strategical frontiers recognized as necessary for the security of Italy. It is hardly necessary to repeat here the results of the fundamental and well-known geographical and geological investigations concerning the region, that is to say, that the Karst and the Dinaric system are integral parts of the Balkan Peninsula, and that the natural boundaries of a peninsula like that of Italy cannot be sought for on the eastern side of the Adriatic. It is very clear even to an untrained observer that this sea marks the natural boundary between the Balkan and Italian peninsulas.

I think I need add nothing to this common-sense view of an essentially simple problem. It is not I, but Commander Roncagli who [illegible] method of the German geographers in using geological [illegible] in a vain effort to prove that the eastern shore of the [illegible] part of the western shore.

Prof. Cvijić's reply to my address of February 10 has caused me a certain surprise. I am afraid he has misunderstood much of what I said. Therefore I take the opportunity of giving herein a few further explanations. However, before doing this I must declare that on delivering my address I never thought of supporting Italy's claims "by geological and botanical arguments." Indeed, Italy's right to the eastern coast of the Adriatic is so strong as not to need reinforcement by means of natural elements. There are plenty of historical, political, cultural, national, and strategic arguments to support it. The object of my lecture was merely as described in its title, "Physical and Strategic Geography of the Adriatic." I thought it unnecessary to explain that I would

deal with my argument in a quite abstract form, as I really did, and any reader of the *Geographical Journal* can verify this by himself.

Let us now turn to the substance of the matter. As a matter of fact:

1. In Dr. Županić's map to illustrate Yugoslav territorial claims * the line marking the natural boundary between the Appennine and Balkan peninsulas has been drawn running midway down the Adriatic, and as far north as the mouth of the river Isonzo. From that point this line ceases to represent the natural boundary between the two peninsulas; still, it continues in a north-westerly direction to mark the western frontier of the territory claimed by the Yugo-Slavs. This section of the line enters the Italian province of Udine so as to include within the limits of the Yugoslav territorial claims a portion of it. This map is the one to which I referred in my address, when speaking of Yugo-slav cartographers. It is the same one that I showed on the screen. I should also add that now it is used even in official quarters to support Yugoslav claims.

2. I never said that Prof. Cvijić ever attempted to prove "that the natural boundary of the Balkan Peninsula lies west of the Isonzo." The paragraph between lines 7th and 23rd, page 215, of the *Journal* speaks for itself. It contains no statement of this kind, nor is a like statement to be found anywhere in my address.

3. I never said that he would "favour the Po as the northern frontier of Italy," nor did I come to "any other conclusion equally absurd." I only said that, since Prof. Cvijić takes the Adriatic Sea to mark the natural boundary between the Italian and Balkan peninsulas, the logical conclusion to which one must come is that such a boundary "in its overland route, so to say, ought to follow the axis of the River Po." And I gave this conclusion full scientific support. It is not I but scientific logic which leads to it. And I cannot be held responsible for absurd consequences logically drawn from absurd premises.

4. It is true that I asserted that Prof. Cvijić has followed what he calls "the illogical methods of certain German geographers, notably Penck." Yet I hastened to add that he did so "perhaps unwillingly" (see *Journal*, page 215, line 26th). And I roughly explained not only how he had unwillingly happened to follow Penck's absurdities, but also how he, no doubt equally unwillingly, had parted from them in other paragraphs of his note. In fact, saying that "the Karst and the Dinaric system are integral part of the Balkan Peninsula," Prof. Cvijić practically adopts the German morphological theory. Moreover he follows Penck, since the latter refuses to recognize the watershed of the Alpine system † to be the natural boundary between the territories situated on either side of it. On the contrary Cvijić stands against Penck when he refuses to consider the geological, flora, and faunistic elements, since Penck has based on these very elements his theory of the natural boundary between the German and the Italian regions, or, as he says, the region of the dark fir tree from that of the olive tree. I think I need not add more to make this point clear.

I wish the distinguished Serbian geographer would reconsider the matter more carefully, and especially that he would leave aside, as I did, all pre-conceptions in regard to territorial claims. Politics is politics; geography is geography. They can support each other, but the one cannot be substituted

* Map of Yugoslav Territory, by Dr. Niko Županić (issued for the Yugoslav Committee in London), September 1917.

† From a physical point of view there is no discontinuance in the Alpine system down to the Dinaric Alps as far south as Cattaro.

for the other. In the light of pure scientific logic he will see for himself that he has no reason to complain of my impartial and merely abstract reasoning.

RONCAGLI.

Motor versus Rail in Persia

I read with much interest Colonel Crosthwait's letter in the *Geographical Journal* for May. While I agree with most of his premises, I cannot admit his conclusions. In advocating the employment of motor transport in Persia I had in my mind the region where cheap petrol would be available in unlimited quantities, that is in the west. I have not enough personal knowledge of conditions in the east to be able to speak with authority, but I would note that in an interesting lecture before the Central Asian Society, on March 12 last, Colonel Webb Ware was most enthusiastic about the value of motors as feeders for the new Nushki railway.

I consider that cheap transport on the Baghdad–Kermanshah–Hamadan route is a crying need of incalculable importance to British and Indian trade interests. Russia always feared the successful exploitation of this road, because it would have dealt a severe blow to her commercial monopoly in Northern Persia. Is it wonderful that her consular officers saw to it that the road never was safe? All the requisites for a good metalled road are available near at hand, including good road metal, water, and cheap labour. A Russian road company constructed and maintained a good metalled road as far west as Hamadan, but for obvious reasons they omitted to extend it further west! At the present time there is a fair metalled road on to Baghdad, which a motor traffic company would have no difficulty in improving and maintaining. Given a good road and solid tyres, I think that Colonel Crosthwait's objections fall to the ground.

Colonel Crosthwait says that the construction of railways in Persia presents little difficulty. That is probably so on the Baluchistan border, but in the west the succession of passes which everywhere have to be negotiated would heavily increase the cost per mile of construction.

I consider that the true *rôle* of the motor is to act as a pioneer to the railway. Good roads and cheap motor transport would ensure order, prosperity, and increased production of every kind, and in time trade would expand sufficiently to make railways necessary and profitable. When that day comes the motor service could be bodily transferred to fresh routes. In addition to the importance of encouraging British and Indian trade with Persia *viâ* Baghdad, there is a political side which should not be lost sight of. Very large numbers of Persian pilgrims travel over the Hamadan-Baghdad road to the shrines of Mesopotamia. The providing of facilities of travel, combined with care for their comfort and interests while in Mesopotamia (on the lines now adopted for the Mecca route), would have a very great effect in fostering friendly feelings for us. Now that the intrigues of other nations are eliminated, England has an excellent opportunity to cultivate and maintain the friendship of Persia, and to help her to be prosperous and independent. The Baghdad–Khanikin and the Nushki railways are both bound in time to be extended, but until they are let us not throw away the opportunities offered by an efficient motor service *viâ* Kermanshah and Hamadan to Tehran, and from Hamadan *viâ* Sultanabad to Isfahan.

GEORGE S. F. NAPIER, Lieut.-Col.

MEETINGS: ROYAL GEOGRAPHICAL SOCIETY: SESSION 1918–1919

Seventh Afternoon Meeting, 19 May 1919.—Sir Aubrey Strahan in the Chair.

PAPER: The Uses of Geology in War. Captain W. B. R. King.

Thirteenth Evening Meeting, 26 May 1919.—The President in the Chair.

ELECTIONS.—Captain John Bartholomew, M.C.; Lieut. E. J. J. Halsted Hanby; Lieut.-Colonel William Lee Hart; George Howell, F.G.S., M.INST.P.T.; Captain D. A. Hutchison, R.E.; Bernard A. J. Jeffs, F.C.S.; William Alfred J. Pennett; Major Harold Hay Thorburn, C.I.E.; Captain John C. Wood.

PAPER: Recent Journeys in Manchuria. Captain A. de C. Sowerby.

Anniversary General Meeting, 2 June 1919, at 5.30 p.m., in the Hall of the Alpine Club, 23, Savile Row.—The President, Colonel Sir Thomas Holdich, in the Chair.

ELECTIONS.—Colin Campbell Garbett, C.I.E., I.O.S.; Lieut. Arthur Hinckley; Sir William Wilson Hoy, C.B.; Captain Charles F. C. Macaskie; Charles A Pope; Captain Arthur Gilbert Quartley; E. Lloyd Rolfe; Captain Herbert Severn, A.M.I.C.E.; Major Frederick Starnes, D.S.O.; Rev. William J. S. Weir; Miss Florence Yarrow.

The Hon. SECRETARY (Mr. A. P. Maudslay) read the Minutes of the Anniversary Meeting held 27 May 1918.

The PRESIDENT: I now have the honour and the pleasure of presenting the Medals and the Awards of the Society to those gentlemen who have distinguished themselves in geographical fields during the last year and to whom this recognition is due.

The Founder's Medal is awarded to Colonel E. M. Jack, C.M.G., D.S.O., R.E., General Staff, for his geographical work on the Western Front. Colonel Jack went out to France with the original Expeditionary Force, and from the outbreak of the War to the date of the signing of the Armistice was in charge of all the survey and geographical operations required by the British Army in France and Belgium. The work, in addition to the execution of normal surveys under exceptionally difficult conditions, involved the development of certain methods which proved to be vitally important for the efficiency of our armies; such methods, that is, as survey for observation and sound ranging. Under Colonel Jack's direction our armies were better provided with all necessary geographical information and assistance than were any other armies on the Western Front. The organization required to cope with the work soon became the greatest survey force ever employed, and at the time of the Armistice consisted of about 4200 officers and men. The labour, so prolonged, so great, and so successful, of the Field Survey Battalions and their chief, deserve the most signal sign of appreciation that the Society can bestow. These labours constituted by far the largest survey operation in history, and also by far the most important on record from a national point of view. It is with peculiar pleasure that I give this Medal now to so distinguished a member of the Corps to which I once had the honour to belong, and I hope that it may be a token of the good fellowship which will always exist between the Department in which you, Colonel Jack, serve in the War Office and the Royal Geographical Society.

Colonel JACK in accepting the Medal said: I should like to say, Sir, how deeply sensible I am of the great honour that the Royal Geographical Society

has by the award of this Medal conferred on me and, through me, on the geographical service of the British Armies in France. Every officer and man of that service will share my pride in this honour, and will recognize, as highly as I do, the appreciation that has been accorded to our work by this distinguished body of geographers.

The PRESIDENT: The Patron's Medal is awarded to Prof. William Morris Davis, of Harvard University, for his eminence in the development of Physical Geography. He is the most eminent of living American geographers, and has devoted his life to investigations in physical geography and to the teaching of geography as a University subject at Harvard, and as visiting Professor in several European Universities. At the commencement of his career he devoted much attention to meteorology, and his 'Elementary Meteorology, 1894' is a standard work. Later he had practical experience as a geologist on the U.S. Geological Survey. For forty years he has given his main attention to the physical geography of the land surface, on which he has published several books and very many papers, some of the most important of these in the *Geographical Journal*. Prof. Davis has travelled throughout North and South America and Europe, widely in Asia (including an expedition to Turkestan), Africa and Australasia. All the leading geographers of Europe have at one time or another taken part in geographical excursions on a great scale led by Prof. Davis, and have borne witness to his extraordinary grasp of physical features and his power of exposition in the field. As a university teacher he introduced new methods of study, especially in his geographical laboratory at Harvard, which have proved of high value in scientific training. As a theoretical geographer he is known mainly by the completeness with which he worked out the geographical cycle of erosion, and the consequences which follow from the application of the conception. All the work of Prof. Davis, both in the field and in the study, is marked by a forceful originality which has acted as a vivifying stimulus to several generations alike of disciples and critics. It is not too much to say that his writings have been largely instrumental in displacing German in favour of English as the language of advanced work in geography. Mr. Butler Wright has undertaken to accept the Medal on behalf of Prof. Davis, and it is with honour that I give it to so distinguished an American. There has always been a good feeling between American geographers and ourselves, and I hope that this will be a small token that it will continue.

Mr. BUTLER WRIGHT (Councillor of the American Embassy): It is very regretful that Prof. Davis has not the pleasure of being here himself this afternoon, not only to receive this generous tribute but also to hear the generous words which you have used; and also that you should have been deprived, by his sudden absence in Paris, of the pleasure of hearing the American Ambassador, who had consented to receive this Medal. Your loss, however, is my decided gain. I consider it a pleasure and an honour which I should seldom, if ever, claim to either appear in the ranks as a member or much less to address the members of the Royal Geographical Society. I only hope that possibly the liability in our Foreign Service, which sometimes renders us averse to accept orders to very far distant posts, may now be turned into an asset, because by so doing and by possible explorations I might be able to appear here on my merit instead of as so absolutely plausible a proxy as I am.

The PRESIDENT: The Victoria Medal is awarded to Prof. J. W. Gregory, F.R.S., of Glasgow University, for his many important contributions to Geographical Science. He received the Cuthbert Peek Grant in 1894 in recognition

of his admirable journey of exploration in East Africa; he accompanied Sir Martin Conway to Spitsbergen in 1896; he has contributed several valuable papers which have been either read to the Society or published in the *Geographical Journal*, dealing with important questions of physical geography; he has also written other papers of like character, in geological and other journals, and done first-rate research work in connection with surface terrestrial forms. I regret very much that Prof. Gregory is not able to be here himself to receive this Medal, being still away from England on official business. We all know him well by name; he is by no means a new friend to us, and I trust that this recognition of his services will be of permanent satisfaction to himself and his family.

The Murchison Grant is awarded to Dr. W. M. Strong for his journeys and surveys in New Guinea. Much of the best work done for the Society is done by those Colonial officers who, of their love for and devotion to the cause of Geography, are ready to take advantage of tours of duty and opportunity of leave to advance our surveys and our knowledge. Dr. Strong has done some conspicuous service in the very difficult country of Papua. He is still there on duty, and I will ask the Secretary to transmit to him the award with our best wishes for his future success in the field of work where he has done so well.

The Cuthbert Peek Grant is awarded to Dr. Rudmose Brown of the University of Sheffield. He is well known to you as the right-hand man of our friend Dr. Bruce; he accompanied him on the voyages of the *Scotia* and took an important part in the publication of the results of these voyages. He is equally at home in Spitsbergen, and is, I believe, proceeding there again this summer. In recollection of what we heard at a recent meeting we shall give him our best wishes for further successful exploration there, and are glad that he should be going there once more to promote the development of this interesting land and the furtherance of British interests.

The Back Grant is awarded to the Ven. Archdeacon Stuck of Fort Yukon, Alaska. We honour him as a stalwart champion of the Church in this distant land, who in his Archidiaconal visitations has not only made extensive explorations of the coast and the Eskimo settlements, but has special claim to our admiration for his bold and successful ascent of Mount McKinley. Nor must we forget that in his mission hospital at Fort Yukon he has received and restored to health the Canadi[illegible] Stefansson, whose hard journeys in the Arctic [illegible]is life. The Archdeacon is at his post, forward the award to him with our

[illegible] Memorial is awarded to Mr. W. J. Harding King for his investigation of desert conditions in North Africa, and you may find it appropriate that the memorial to Captain Gill established by his sister should go to one whose interest in deserts and desert conditions would have appealed so strongly to that distinguished traveller. Mr. Harding King's work on sand dunes and oases is well known to all readers of the *Journal*. It required great skill and patience with courage and endurance; it makes a substantial contribution to our knowledge of the fascinating problems of shifting sand; and we hope to hear of more work on the lines so well laid down, now that the deserts of North Africa bid fair to be more accessible and less dangerous than they were before the war.

The President then delivered his Anniversary Address which is printed on page 1.

The President appointed Captain Wilson Barker and Mr. B. R. Shepherd to be scrutineers of the ballot.

The Annual Report of the Council with the Auditors' Report and the Accounts for 1918 were presented to the meeting.

The meeting proceeded to the election by ballot of the President and Council for the ensuing year (see page iv).

Sir FRANCIS YOUNGHUSBAND: I think we ought to take this opportunity to thank our retiring President for all his zealous work for the Society during his tenure of office. He is a man who knows geographical science from A to Z. He has been all about the world; he has conducted great survey operations; and has been of much benefit to the Society. I am sure it is a matter of regret to us all that on account of his health he is unable to give us the benefit of another year of his great experience. I wish to propose a very hearty vote of thanks to Sir Thomas Holdich, and to wish him many years still of service to the Society.

Major LEONARD DARWIN: I should like to be permitted as a past President of this Society and as a very, very old friend of Sir Thomas Holdich to second the vote of thanks. You know his work whilst he has been President. I look back for many many years before that. His work in South America was so remarkable and brought so much credit on geography that I think it directly led to this Society being appointed an arbitrator in an international dispute. I should also like for one moment to look back still further to the time when I was an Honorary Secretary of this Society. There was a good deal of stress and strain with regard to Antarctic exploration. At that time—there are not many here who remember it as well as I do—Sir Thomas Holdich came forward and helped us in a way that was extraordinarily useful to the Society. He took a difficult and disagreeable part, and I have felt ever since that we owe a deep debt of gratitude to him.

The PRESIDENT: I thank you cordially for your kind recognition of my work. But, as President of this meeting I must remark that the action of my old friend, Sir Francis Younghusband, and my still older friend, Major Leonard Darwin, is just a little premature. I think that this is the best opportunity to tell you that at a meeting of the Council of the Society on May 12 the following resolution was adopted:—

> "That the President, Officers and Council elected at the Annual General Meeting of the Society shall henceforth enter into office at the beginning of the next session in the following autumn, and that the outgoing President, Vice-Presidents, and Council shall retain office until that date."

So you see you have not got rid of me altogether yet. There is still a dinner to be negotiated, and we have the final meeting of the session on June 16.

Fourteenth Evening Meeting, 16 June 1919. The President in the Chair.

ELECTIONS.—Captain James U. F. C. Alexander; Captain Herbert Alnwick, M.C.; Rev. G. A. Barclay; Udo de Berker; Major B. Burgess, R.E.; Charles Fillingham Coxwell, M.D.; Philip W. George; William R. Giles; Leslie Gordon; Sidney F. Harmer; Mrs. Rose Keefer; Captain Robert A. MacLean; Thomas McCulloch; William McDonald; Lieut. Norman G. Roskruge; Brig.-General H. Rowan-Robinson, D.S.O., R.A.; Captain Arthur C. Sykes, D.S.O., O.B.E., R.E.; Colonel John K. Tod, I.A.; Ronald E. L. Wingate.

PAPER: The Paraguayan Chaco and its Possible Future. Mr. W. Barbrooke Grubb.